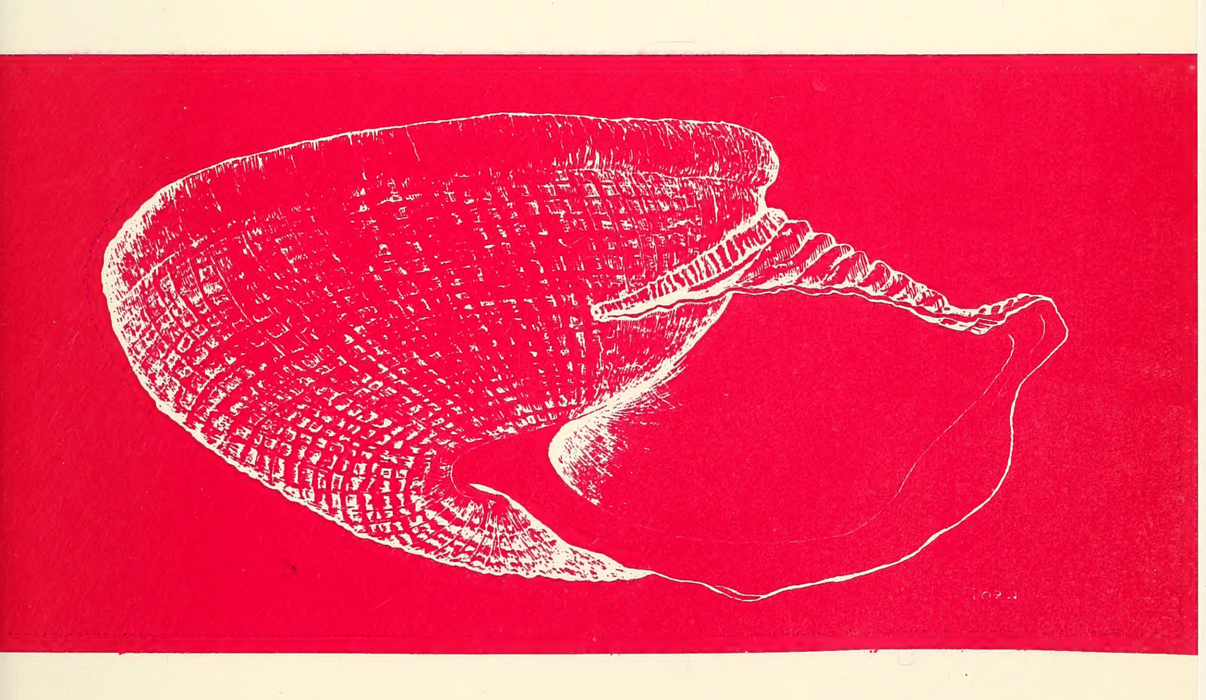
Iberus

Vol. 20 (2)

REVISTA DE LA SOCIEDAD ESPAÑOLA DE MALACOLOGÍA



Oviedo, diciembre 2002

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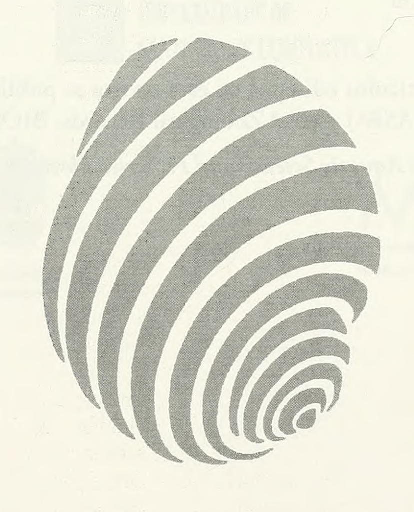
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Portada de *Iberus*

Iberus gualterianus (Linnaeus, 1758), una especie emblemática de la península Ibérica, que da nombre a la revista. Dibujo realizado por José Luis González Rebollar "Toza".

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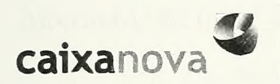
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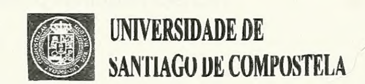


















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Revisión taxonómica de *Cionella (Hohenwarthia) disparata* Westerlund, 1892 (Gastropoda Pulmonata: Fesussaciidae)

Taxonomical revision of *Cionella (Hohenwarthia) disparata* Westerlund, 1892 (Gastropoda Pulmonata: Fesussaciidae)

Alberto MARTÍNEZ-ORTÍ*

Recibido el 9-XI-2001. Aceptado el 14-I-2002

RESUMEN

Se realiza un estudio conquiológico y anatómico de *Cionella (Hohenwarthia) disparata* Westerlund, 1892, tras la revisión de material museístico y la recolección de ejemplares vivos en la localidad típica. Se compara con *Hohenwartiana eucharista* (Bourguignat, 1864) y se concluye que *Cionella (Hohenwarthia) disparata* Westerlund, 1892 debe considerarse un sinónimo posterior de dicha especie. Se estudian las series tipo de *Cionella disparata* y *Ferussacia terveri* Bourguignat, 1856 y se da a conocer la distribución geográfica de *H. eucharista* en la Península Ibérica.

ABSTRACT

After the revision of museum material and the collection of live samples from the type locality, a conchological and anatomical study of *Cionella (Hohenwarthia) disparata* Westerlund, 1892, has been made. It has been compared to *Hohenwartiana eucharista* (Bourguignat, 1864) and the conclusion that *Cionella (Hohenwarthia) disparata* Westerlund, 1892 must be considered as a junior synonym of the aforementioned species, has been drawn. The type series of *Cionella disparata* and *Ferussacia terveri* Bourguignat, 1856, have been studied and the current geographical distribution of *H. eucharista* in Iberian Peninsula has been made known.

PALABRAS CLAVE: Ferussaciidae, *Ferussacia disparata*, *Ferussacia terveri*, *Hohenwartiana eucharista*, taxonomia, sinonimia, España.
KEY WORDS: Ferussaciidae, *Ferussacia disparata*, *Ferussacia terveri*, *Hohenwartiana eucharista*, taxonomy, synonymy, Spain.

INTRODUCCIÓN

Cionella (Hohenwarthia) disparata es un ferussácido descrito por WESTERLUND (1892a), como similar a *Cionella hohenwarthi* Rossmässler, 1839, en Cataluña con localidad típica "Spanien, bei Barcelona" (España, en Barcelona), y conocido actualmente como *Ferussacia disparata* (HAAS, 1929; BECH, 1990; ALTABA Y BALLESTEROS, 1991). También ha sido citado en otras localidades de las provincias de Girona, Barcelona y Tarragona. Todas estas determinaciones fueron realizadas teniendo en cuenta la morfología de la concha y la mayoría de

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las citas han sido recopiladas y transcritas de unos autores a otros.

Dada la confusión taxonómica existente en torno a esta especie, el autor ha muestreado en los últimos años intensamente los alrededores de Barcelona, con el fin de recolectar ejemplares vivos que contribuyan a esclarecer su estatus taxonómico y su posición genérica. Tanto la concha como el aparato reproductor de los ejemplares recolectados en la localidad típica de *F. disparata*, como las muestras museísticas que han podido ser localizadas, se han comparado con ejemplares de *Hohenwartiana eucharista* (Bourguignat, 1864), ferussácido sólo citado por CHÍA (1916) en Cataluña con este nombre, y que está presente y bien caracterizado en la Comunidad Valenciana (GASULL, 1975, 1981; MARTÍNEZ-ORTÍ, ROBLES, MARTÍNEZ-LÓPEZ Y RODRÍGUEZ, 1991; MARTÍNEZ-ORTÍ, 1999). Además se han estudiado las series tipo de *Cionella disparata* y de *Ferussacia terveri*, para una mayor clarificación del estatus taxonómico de la primera y para intentar establecer su relación con la segunda, seleccionándose además el lectotipo de ambas especies. Se da a conocer la rádula de *F. terveri* tras el hallazgo de su bulbo bucal en el interior de uno de los sintipos. Finalmente se da a conocer la distribución geográfica actualizada de *H. eucharista* en la Península Ibérica.

MATERIAL Y MÉTODOS

En los últimos años se han realizado muestreos continuados en el área alrededor de Barcelona y se han recolectado 13 ejemplares en "El Prat de Lloblegat, la Camparra" (31TDF2574) (MVHN, Nº 700), muy cerca de Barcelona, que corresponde a la localidad típica de *F. disparata*. El material de *H. eucharista* utilizado para su comparación procede de "Alberic, río Xúquer" (Valencia, YJ1330) (col. Martínez-Ortí, Nº 361= Nº 701, MVHN) (MARTÍNEZ-ORTÍ *ET AL.*, 1991)

Se han revisado y comparado muestras conquiológicas determinadas como *Ferussacia disparata*, *F. terveri* y *H. eucharista*, depositadas en el Museu de Zoologia de Barcelona (MZB, colecciones Aguilar Amat, Bofill, Chía, Gasull y Rosals), Museu Valencià d'Història Natural de Valencia (MVHNV, muestras procedentes de las colecciones Altimira, Chía y Vilella, depositadas en la col. Siro de Fez y col. Martínez-Ortí), Swedish Museum of Natural History de Estocolmo (SMNHS, col. Westerlund) y en el Muséum d'Histoire Naturelle de Ginebra (MHNG, col. Bourguignat).

El estudio de la rádula de *F. terveri*, hallada en uno de los sintipos, se ha realizado tras eliminar la materia orgánica del bulbo bucal, por ebullición en solución acuosa con sosa. Posteriormente se ha fotografiado en el microscopio electrónico de barrido, HITACHI S-4100, del Servicio de Microscopía de la Universitat de València.

RESULTADOS Y DISCUSIÓN

La determinación de las especies de los géneros *Ferussacia* y *Hohenwartiana* (Familia Ferussaciidae) presentan gran dificultad (Altonaga, Gómez, Martín, Prieto, Puente y Rallo, 1994). Por ello consideramos de gran interés el estudio del aparato reproductor de los ejemplares recolectados en la localidad típica de *F. disparata*, así como el estudio conquiológico de las muestras museísticas, en las que se incluye las series tipo de los táxones objeto de estudio.

Recopilación bibliográfica: WESTERLUND (1892b) cita esta especie con la combinación *Hohenwarthia disparata*. SALVANÁ (1884) cita *Ferussacia hohenwartii* en "Vallvidrera" (Barcelona, DF2586), "Girona" (DG8547) y "S'Agaró" (EG0427, Girona) mientras que BOFILL Y HAAS (1920) la reasignan a *Ferussacia terveri* (Bourguignat, 1856). Otros autores, como CHÍA (1887), SALVAÑÁ (1887) y BOFILL (1915) citan *F. terveri* en "los alrededores del cementerio del Sudeste, Parque en Barcelona" (DF2978), Bofill (1890) en la "Ciutadella" (Barcelona, DF3283) y en el "Parque de Montjuich (DF3079) y cerca del cementerio



Figuras 1-4. *Hohenwartiana eucharista*. 1: "Alberic, río Xùquer (Valencia, YJ1330)" (col. Martínez-Ortí, Nº 701 MVNH; 6,7 mm H; 2,25 mm Ø); 2: "Barcelona" (col. Chía, Nº 568 MVHN; 6,55 mm H; 2,2 mm Ø); 3: "Cantunis" (col. Vilella, Nº 569 MVHN; 6,1 mm H; 2,1 mm Ø); 4: "La Camparra, El Prat de Llobregat" (col. Martínez-Ortí, Nº 700 MVHN; 7,2 mm H; 2,3 mm Ø). Figura 5. Lectotipo de *Cionella (Hohenwarthia) disparata* Westerlund, 1892 (col. Westerlund, Nº 5303 SMNHS, 6,5 mm H; 2,2 mm Ø). Figura 6. *Ferussacia (Pegea) terveri* Bourguignat, 1856 (col. Bourguignat, Nº 10179 MHNG). 6a: Lectotipo (7,45 mm H; 2,4 mm Ø); 6b: paralectotipo (6,4 mm H; 2,1 mm Ø); 6c: detalle de la abertura del paralectotipo.

Figures 1-4. Hohenwartiana eucharista. *1: "Alberic, río Xùquer (Valencia, YJ1330)" (Martínez-Ortí coll., Nº 701 MVHN; 6.7 mm H; 2.25 mm Ø); 2: "Barcelona" (Chía coll., Nº 568 MVHN; 6.55 mm H; 2.2 mm Ø); 3: "Cantunis" (Vilella coll., Nº 569 MVHN; 6.1 mm H; 2.1 mm Ø); 4: "La Camparra, El Prat de Llobregat" (Martínez-Ortí coll., Nº 700 MVHN; 7.2 mm H; 2.3 mm Ø). Figure 5. Lectotype of* Cionella (Hohenwarthia) disparata *Westerlund, 1892 (Westerlund coll., Nº 5303 SMNHS; 6.5 mm H; 2.2 mm Ø). Figure 6.* Ferussacia (Pegea) terveri *Bourguignat, 1856 (Bourguignat coll., Nº 10179 MHNG). 6a: Lectotype (7.45 mm H; 2.4 mm Ø); 6b: paralectotype (6.4 mm H; 2.1 mm Ø); 6c: detail of the paralectotypes' aperture.*

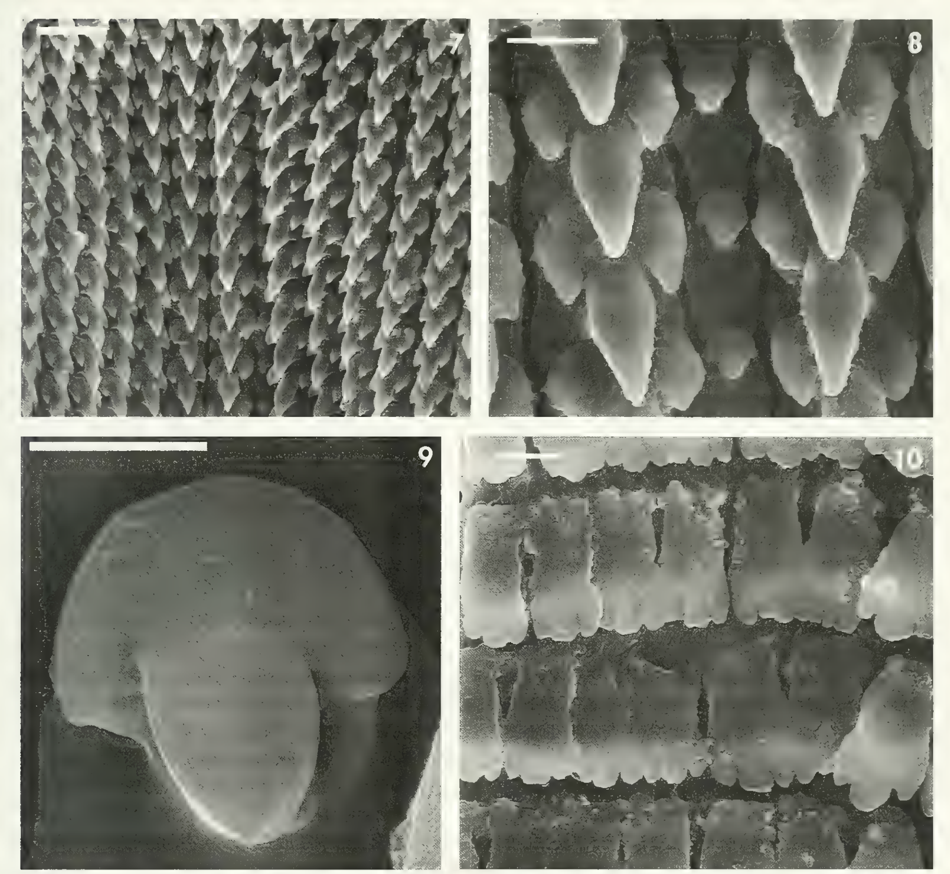
nuevo" (Barcelona), SAINT SIMON (1891) en "Barcelona" y ZULUETA (1904) en "Aluvions de la vora dreta del Llobregat, prop de sa desembocadura". Estas asignaciones a *F. terveri* se fundamentan en la determinación que Bourguignat realizó de ocho ejemplares de Barcelona enviados por Salvañá (SALVAÑÁ, 1887). Tras la revisión de estos ejemplares, depositados en el MHNG (Nº 9947), se ha comprobado que realmente corresponden a *H. eucharista*. Pilsbry (1908) recopila la cita de Westerlund, de "cerca de Barcelona". CHÍA (1916) cita *Hohenwarthia eucharista* en "S'Agaró, riera d'en Xuncla". HAAS (1929) cita *F. disparata* de "Barcelona", "Valle del Llobregat", "Girona", "S'Agaró" y "aluviones del Ebro" (Tarragona), y más recientemente, ALTIMIRA (1969) de "l'Arana" (Prat de Llobregat, DF2773), Casa Antúnez (Cantunis, Barcelona) (DF2978) y Farola (Far) del Llobregat (DF2975)". Actualmente *Ferussacia disparata* continúa formando parte del elenco de especies de la malacofauna catalana (BECH, 1990; ALTABA Y BALLESTEROS, 1991).

Estudio de la serie tipo de *Cionella (Hohenwarthia) disparata* Westerlund, 1892: Se ha examinado un sintipo perteneciente a la serie tipo de *C. disparata* con localidad tipo "en Barcelona" (Nº 5303, col. Westerlund, SMNHS) (Fig. 5). Se ha seleccionado este ejemplar como lectotipo de *Cionella disparata*. Sus dimensiones son 6,5 mm de altura y 2,2 mm de diámetro. Otros cinco sintipos, no revisados, de *C. disparata* (K. Sinderman, com. per), que se encuentran depositados en el Natural History Museum de Gotemburgo (Suecia), se consideran paralectotipos.

Estudio de la serie tipo de *Ferussacia terveri* Bourguignat, 1856: BOURGUIGNAT (1856) no indica una localidad exacta sino que señala como localidad típica los alrededores de Argel y de Orán. Posteriormente, BOURGUIGNAT (1864) detalla con mayor precisión la procedencia de las muestras de este taxon, dando a conocer un total de seis localidades. Bourguignat selecciona como serie tipo de *F. terveri* la muestra Nº 10179 (MHNG), con localidad "Mustapha, à la Maison-Carrée", en los alrededores de Argel, ya que manuscribe en la etiqueta la palabra "type". Esta localidad debe considerarse como localidad típica restringida. Está compuesta por ocho sintipos cuyas dimensiones máximas son: 7,6 mm de altura y 2,65 mm de diámetro.

En su descripción original BOURGUIGNAT (1856) no advierte la presencia de la lamela parietal, presente en todos los sintipos, ni figura la especie. Sin embargo, en 1864 (Lám. 5, Figs. 1-3), completa la descripción y publica una figura que no ha podido ser asociada a ninguno de los sintipos revisados. Por ello se ha seleccionado como lectotipo de *Ferussacia terveri* el ejemplar que presentaba en su interior el bulbo bucal (Fig. 6a), ya que ha permitido descubrir la rádula de la especie. Sus dimensiones son 7,45 mm de altura y 2,4 mm de diámetro. Los otros 7 sintipos corresponden a paralectotipos de esta especie. Solamente en dos de los sintipos se observa la lamela parietal frontalmente, uno de los cuales corresponde al lectotipo, mientras que en los otros debe realizarse un leve giro en la concha para observarla (Figs. 6b-c). Además todos los sintipos presentan dos pliegues columelares (Fig. 6c), excepto uno de ellos que presenta sólo uno. La presencia de estas características morfológicas de la concha, la lamela parietal y los pliegues columelares, nos permite asignar *Ferussacia terveri* al subgénero *Pegea* (Risso, 1826) (ZILCH, 1958-60).

La rádula del lectotipo de *F. (Pegea) terveri* presenta 37 dientes por hemirádula (Figs. 7-10), con una morfología similar a la que presentan *Ferussacia (Ferussacia) folliculus* (Gmelin, 1791) y *H. eucharista*, no apreciándose diferencias significativas con las de éstas (MARTÍNEZ-ORTÍ *ET AL.*, 1991). Se ha observado que algunos dientes marginales contiguos presentan sus cúspides fusionadas (Fig. 10). La mandíbula presenta las mismas características morfológicas que otros ferussácidos (MARTÍNEZ-ORTÍ *ET AL.*, 1991; GIUSTI, MANGANELLI Y SCHEMBRI, 1995).

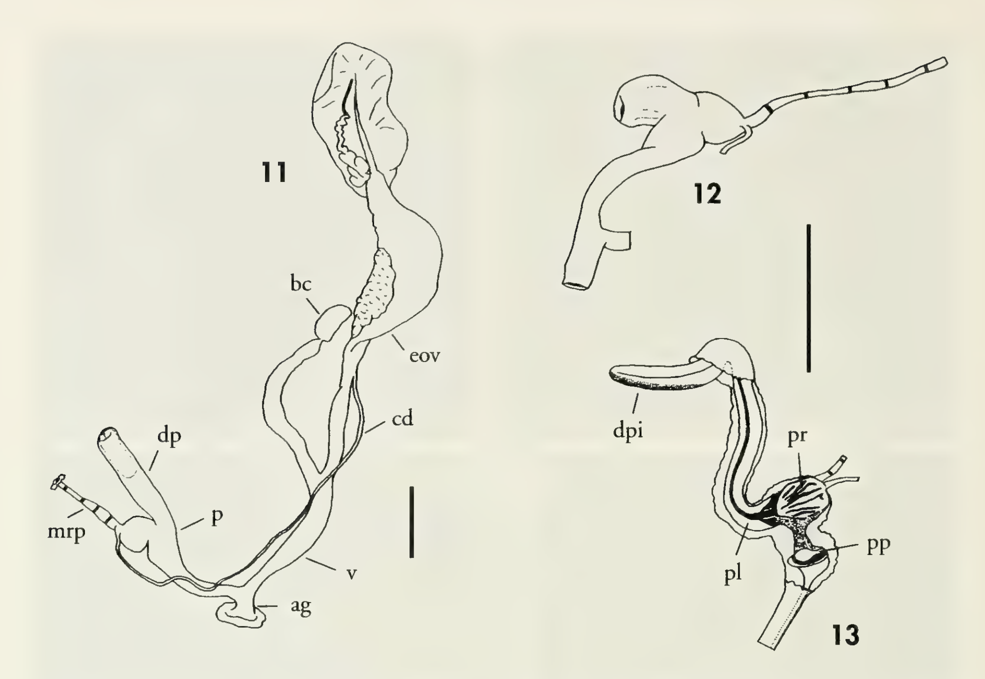


Figuras 7-10. Rádula del lectotipo de *Ferussacia terveri* (col. Bourguignat, Nº 10179 MHNG) (M.E.B.). 7: Vista general; 8: diente central y primeros laterales; 9: detalle del diente central; 10: dientes marginales. Escalas, 7: 25 µm; 8: 10 µm; 9: 2,5 µm; 10: 5 µm.

Figures 7-10. Radula of the lectotype of Ferussacia terveri *(Bourguignat coll., Nº 10179 MHNG) (S.E.M.). 7: General view; 8: central and first lateral teeth; 9: detail of the central tooth; 10: marginal teeth. Scale bars, 7: 25 µm; 8: 10 µm; 9: 2,5 µm; 10: 5 µm.*

Revisión de muestras del MZB: Se han estudiado siete muestras que se reasignan a *Hohenwartiana eucharista*, todas ellas procedentes de la localidad típica: Nº 79-8184: 36 conchas, col. Chía, "Cantunis" (Barcelona); Nº 79-8218: 47 conchas, *F. terveri*, col. Bofill, "Cantunis"; Nº 79-8219: 2 conchas, *F. terveri*, col. Rosals, "Barcelona"; Nº 79-8220: 4 conchas, *F. terveri*, "Barcelona"; Nº 79-8221: 2 conchas, *F. terveri*, col. Aguilar-Amat, "Cantunis (Barcelona); Nº 79-8222: 4 conchas, "aluvions esquerra del Llobregat"; Nº 79-8223: 18 conchas, *Ferussacia* sp. ind., col. Chía, "Barcelona"; Nº 79-8225: 2 conchas, col. Bofill, "Barcelona, parque de la Ciutadella". Además se han revisado las muestras publicadas por GASULL (1975, 1981), confirmándose su asignación específica a *H. eucharista*.

Revisión de muestras del MVHN: Col Siro de Fez: Nº 568: 11 conchas, *F. terveri*, col. Chía, "Barcelona", formaba parte de la depositada en el MZB (Nº 79-8223); Nº 569: 14 conchas, *F. disparata*, col. Vilella, "Can Tunés" (Cantunis Bar-



Figuras 11-13. Aparato reproductor de *Hohenwartiana eucharista* (Bourguignat, 1864), Col. Martínez-Ortí, Nº 700 MVHN, "La Camparra, El Prat de Llobregat (Barcelona)". 11: Esquema general (escalas, 1 mm); 12: detalle del pene; 13: estructura interna del complejo penial. Abreviaturas: ag: atrio genital; bc: bursa copulatrix; cd: conducto deferente; dp: divertículo penial; dpi: divertículo penial introflexionado; p: pene; pl: pliegue longitudinal; pr: pliegues radiales; pp: papila penial; v: vagina.

Figures 11-13. Reproduction organs of Hohenwartiana eucharista *(Bourguignat, 1864), Col. Martínez-Ortí, Nº 700 MVHN, "La Camparra, El Prat de Llobregat (Barcelona)" (scale bars, 1 mm). 11: General view; 12: detail of the penis; 13: internal structure of the penial complex. Abbreviations: ag: atrium; bc: bursa copulatrix; cd: vas deferent; dp: diverticulum penial; dpi: diverticulum penial introflected; p: penis; pl: longitudinal pleat; pr: radial pleats ; pp: penis papilla; v: vagina.*

celona); Nº 570: 11 conchas, *F. disparata*, col. Altimira, "Barcelona, Prat de Llobregat, en el antiguo campo de Polo del final de la Diagonal". Las tres muestras corresponden a *H. eucharista*.

Col. Martínez-Ortí: véase MARTÍNEZ-ORTÍ *ET AL.* (1991) y MARTÍNEZ-ORTÍ (1999).

Estudio de la genitalia: Se han diseccionado cinco ejemplares procedentes de "La Camparra, El Prat de Llobregat (Barcelona)", localidad típica de *F. dis*parata. Se han representado el aparato reproductor completo de un ejemplar, un pene de otro ejemplar y la estructura interna del complejo penial de otro (Figs. 11-13). Las características morfológicas del aparato reproductor coinciden con las que presentan los ejemplares valencianos descritos por Gittenberger (*in* GASULL, 1975), MARTÍNEZ-ORTÍ *ET AL.* (1991) y MARTÍNEZ-ORTÍ (1999). Se ha observado una gran variabilidad en la longitud del divertículo penial, al igual que en los ejemplares valencianos. Hay que indicar que, en nuestra opinión, no se existen diferencias significativas, ni en la estructura interna del complejo penial ni en el resto del aparato reproductor, con las de *Hohenwartiana hohenwarti* (Rossmässler, 1838) representadas por GIUSTI *ET AL.* (1995).

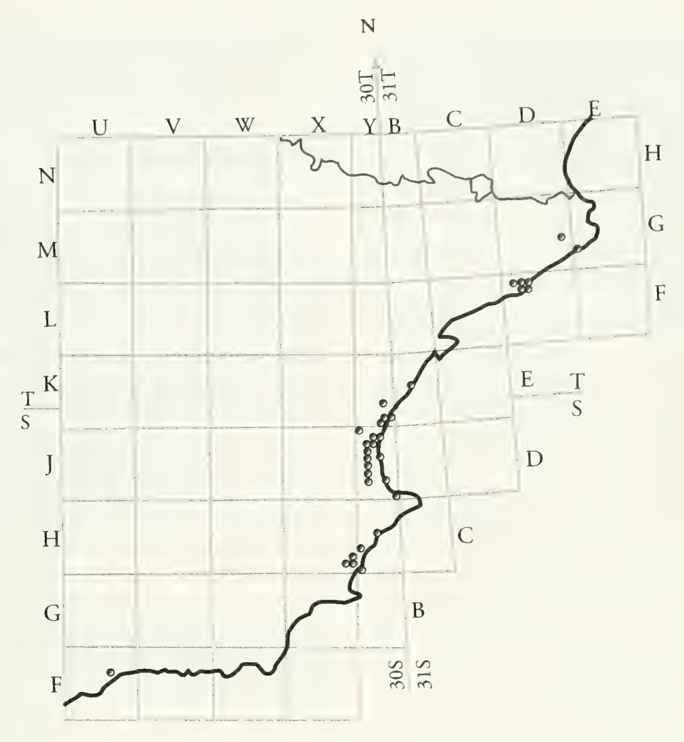


Figura 14. Distribución geográfica de *Hohenwartiana eucharista* en la Península Ibérica.
Figure 14. Geographic distribution of Hohenwartiana eucharista *in Iberian Peninsula.*

Distribución y hábitat: *Hohenwartiana eucharista* se extiende, en la Península Ibérica, por Cataluña, Comunidad Valenciana (GASULL, 1975, 1981; MARTÍNEZ-ORTÍ *ET AL.*, 1991; ALTONAGA *ET AL.*, 1994; MARTÍNEZ-ORTÍ, 1999) y Andalucía. Recientemente hemos estudiado material de esta especie, recolectado por J. S. Torres en la provincia de Málaga, de El Tarajal (UF6562), Polígono industrial Santa Bárbara (UF6961) y los Prados (UF6862) (Fig. 14). Además, su distribución podría ampliarse con las citas de HAAS (1929), SERVAIN (1880), MEDINA (1888, 1891) y ZULUETA (1904), todas ellas procedentes de aluviones, aunque sería necesario su revisión para considerarlas válidas, dadas las dificultades de determinación que hemos señalado.

Como se puede observar en la Figura 14, la distribución de esta especie presenta discontinuidades a lo largo de la costa mediterránea, que probablemente están relacionadas con el muestreo insuficiente de algunas áreas.

Habita en ambientes de huerta, cultivos de cítricos, de ribera, márgenes de acequias, etc., a baja altitud, no superando los 140 m en la Comunidad Valenciana (MARTÍNEZ-ORTÍ, 1999).

CONCLUSIONES

De acuerdo con las observaciones realizadas sobre la concha y el aparato reproductor de ejemplares vivos de la localidad típica de *Ferussacia disparata*, así como con el estudio de las series tipo de *Cionella (Hohenwarthia) disparata* Westerlund, 1892 y *Ferussacia terveri* Bourguignat, 1856 y su comparación con abundante material de *Hohenwartiana eucharista* de las colecciones Gasull y

Martínez-Ortí, podemos concluir que *Cionella disparata* Westerlund, 1892 debe ser considerado un sinónimo posterior de *Hohenwartiana eucharista* (Bourguignat, 1864). Por otra parte, *Ferussacia terveri* Bourguignat, 1856 se incluye, tras la revisión del material tipo, en el género *Ferussacia (Pegea)*. Las citas de esta especie en Cataluña corresponden, en realidad, a *H. eucharista*.

Nota añadida durante la impresión: Estando en prensa este trabajo Falkner, Ripken y Falkner (2002, *Col. Patrimoines Naturels del M.N.H.N. París*, 52: 116, nota 183) han revisado el tipo de *Ferussacia eucharista* Bourguignat 1864 y han comprobado que pertenece al género *Cecilioides* A. Férussac 1814, dando a conocer la nueva combinación *Cecilioides eucharista*. Por ello, la especie tradicionalmente determinada como *Hohenwartiana eucharista* en la Península Ibérica debe cambiar de nombre. Proponemos la nueva combinación *Hohenwartiana disparata* (Westerlund 1892) para esta especie, ya que es el nombre específico más antiguo asignado a esta especie.

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On the synonymy between *Aplysia winneba* Eales, 1957 and *Aplysia fasciata* Poiret, 1789 (Mollusca: Opisthobranchia: Anaspidea)

Sobre la sinonimia entre *Aplysia winneba* Eales, 1957 y *Aplysia fasciata* Poiret, 1789 (Mollusca: Opisthobranchia: Anaspidea)

Eugenia MARTÍNEZ * and Jesús ORTEA**

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ABSTRACT

The anatomy and geographical range of the opisthobranch mollusc *Aplysia fasciata* Poiret, 1789, a species widely distributed in East Atlantic and Mediterranean waters, are reviewed. A detailed anatomical description of this species is given, and radula, jaw elements and palatal teeth are illustrated using the scanning electron microscope (SEM).
Examination of the type material of *Aplysia winneba* Eales, 1957, originally described from Ghana, revealed that this species is a synonym of *Aplysia fasciata* Poiret, 1789. Literature references to *Aplysia brasiliana* Rang, 1828 in the eastern Atlantic are missidentifications of some specimens of *Aplysia fasciata*, deposited in the Natural History Museum of London.

RESUMEN

En este trabajo se revisan la anatomía y la distribución geográfica de *Aplysia fasciata* Poiret, 1789, una especie ampliamente distribuida en el Atlántico Este y en el Mediterráneo. Se da una detallada descripción anatómica de esta especie, y se describen la rádula, armadura labial y elementos palatales usando el microscopio electrónico de barrido.
El exámen del material tipo de *Aplysia winneba* Eales, 1957, descrita originalmente en las costas de Ghana, nos lleva a proponer la sinonimia entre esta especie y *Aplysia fasciata* Poiret, 1789. Por otra parte, las referencias en la literatura a la especie *Aplysia brasiliana* Rang, 1828, en aguas del Atlántico oriental son debidas a una incorrecta identificación de algunos ejemplares de *A. fasciata* depositados en las colecciones del Natural History Museum de Londres.

KEY WORDS: *Aplysia fasciata*, *Aplysia winneba*, opisthobranchs, Anaspidea, East Atlantic, taxonomy.
PALABRAS CLAVE: *Aplysia fasciata*, *Aplysia winneba*, opistobranquios, Anaspidea, Atlántico este, taxonomía.

INTRODUCTION

Members of the opisthobranch family Aplysiidae are characterised by having a globose body and two well developed and symmetrical parapodia that, in some cases, are joined posteriorly. A flat shell is always present, and

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the body surface is smooth, without any tubercles. A more complete description can be found in EALES (1960) and BEEMAN (1968). The family includes two genera, *Aplysia* Linnaeus, 1767 and *Syphonota* Adams, 1854, the latter being a circumtropical genus. *Syphonota* differs from *Aplysia* by the position of the rhinophores, close together and set back almost between the parapodial flaps, rather than in front of them (EALES, 1960).

Species of *Aplysia* has been usually differentiated on the basis of external characters, mainly the size and shape of the parapodial lobes, the size of the mantle foramen and the shape of the shell, as well as the penial morphology (EALES, 1960; THOMPSON, 1976). The morphology of the hard parts of the buccal mass, and mainly of the radular teeth, has been also used, but radular morphology has been not studied with detail in all species belonging to this genus.

The Aplysiidae of European and West African shores and of the Macaronesian Islands have been previously studied in several papers: RISBEC, 1931; ODHNER, 1932; GRIGG, 1949; PRUVOT-FOL, 1953; GANTÉS, 1956; EALES, 1957a, 1957b; BEBBINGTON AND THOMPSON, 1968; BEBBINGTON, 1970, 1975; BEBBINGTON AND BROWN, 1975; THOMPSON, 1976; EDMUNDS, 1978; BEBBINGTON, 1982; BALLESTEROS AND TEMPLADO, 1987; ORTEA AND MARTÍNEZ, 1991; MALAQUIAS AND CALADO, 1997; WIRTZ AND MARTINS, 1993, among others. In her world-wide revision of the genus *Aplysia* EALES (1960) recorded 35 species, nine of which inhabit East Atlantic waters: *Aplysia parvula, A. punctata, A. fasciata, A. dactylomela, A. brasiliana, A. winneba, A. depilans, A. juliana* and *A. dura*.

Despite this proliferation of papers, a review of some problematic species seemed to be necessary to have a more complete knowledge of the East Atlantic Aplysiidae. Among them, the validity of the species *Aplysia winneba*, originally described from Ghana shores and, subsequently, only recorded from Cape Verde (EALES, 1957a) and from Senegal (EDMUNDS, 1978; BEBBINGTON, 1982). The main objective of the present paper is to clarify the identity of *Aplysia winneba*, on the basis of a re-examination of the type material and additional specimens assigned to *Aplysia fasciata*. Another question is the reference to *Aplysia brasiliana* as an amphiatlantic opisthobranch, after two records made by EALES (1960) off Saint Helena and Ghana shores. East Atlantic specimens of *A. brasiliana* studied by Eales are also re-examined, in orden to clarify the possible alleged amphiatlantic character of this species.

MATERIAL AND METHODS

The specimens studied in this paper were collected by the authors, provided by some colleagues or borrowed from the following institutions: MNCN Museo Nacional de Ciencias Naturales, Madrid; MNHN Muséum National d' Histoire Naturelle, Paris; NHM Natural History Museum, London.

Several specimens were dissected and hard parts of the buccal bulb were studied by scanning electron microscopy (SEM).

SYSTEMATICS

Family Aplysiidae Lamarck, 1809

Genus *Aplysia* Linnaeus, 1767

Aplysia fasciata Poiret, 1789

Aplysia fasciata Poiret, 1789, *Voy. Barbarie*, 2: 2 [Type locality: shores of Barbarie (around El Kala, East of Algeria)].

Tethys leporina Linnaeus, 1758, *Syst. Nat.*, 10: 563 (non *Tethys leporina* Linnaeus, 1767, *Syst. Nat.*, 12: 1089 - Nudibranchia).
Aplysia alba Cuvier, 1803, *Ann. Mus. d' Hist. Nat.*, 2: 295, Pl. I, fig. 6.
Aplysia camelus Cuvier, 1803, *Ann. Mus. d' Hist. Nat.*, 2: 295, Pl. I, fig.1.
Aplysia napolitana delle Chiaje, 1823, *Mem. sulla storia e notomia degli anim. s. vert. del Reg. di Napoli*, 1: 31,39, 70, Pl. III, fig. 2.
Aplysia vulgaris de Blainville, 1823, *J. Phys. Chim. Hist. Nat. et des Arts*, 96: 285, figs. 1-2.
Aplysia marmorata de Blainville, 1823, *J. Phys. Chim. Hist. Nat. et des Arts*, 96: 286, figs. 3-4.
Dolabella lepus Risso, 1826, *Hist. Nat. de l' Europe mérid.*, 4: 44, Pl. I, figs. 1-2.
Aplysia radiata Crouch, 1826, *Illustr. Introd. Lam. Conch.*: 44, Pl. XIV, figs. 10, 10a.
Aplysia lepus (Risso): Philippi, 1844, *Enum. Moll. Sicil.*, 2: 99.
Aplysia cameliformis Locard, 1886, *Ann. Soc. Agric. Lyon*, 8: 66.
Aplysia winneba Eales, 1957, *Proc. Malac. Soc. London*, 32 (4): 180-183, figs. 1-6 (*sin. nov.*)
Aplysia gracilis Eales, 1960, *Bull. British Mus. (Nat. Hist.), Zoology*, 5: 320-321, fig. 26.

EALES (1960: 315) included *A. limacina* de Blainville, 1823, among the synonyms of *Aplysia fasciata*, although the specimen figured by de Blainville is clearly not an *Aplysia*, but rather a *Phyllaplysia*. There are several subsequent references to *A. fasciata* as *A. limacina* (GRIGG, 1949; IMPERATO, MINALE AND RICCIO, 1977).

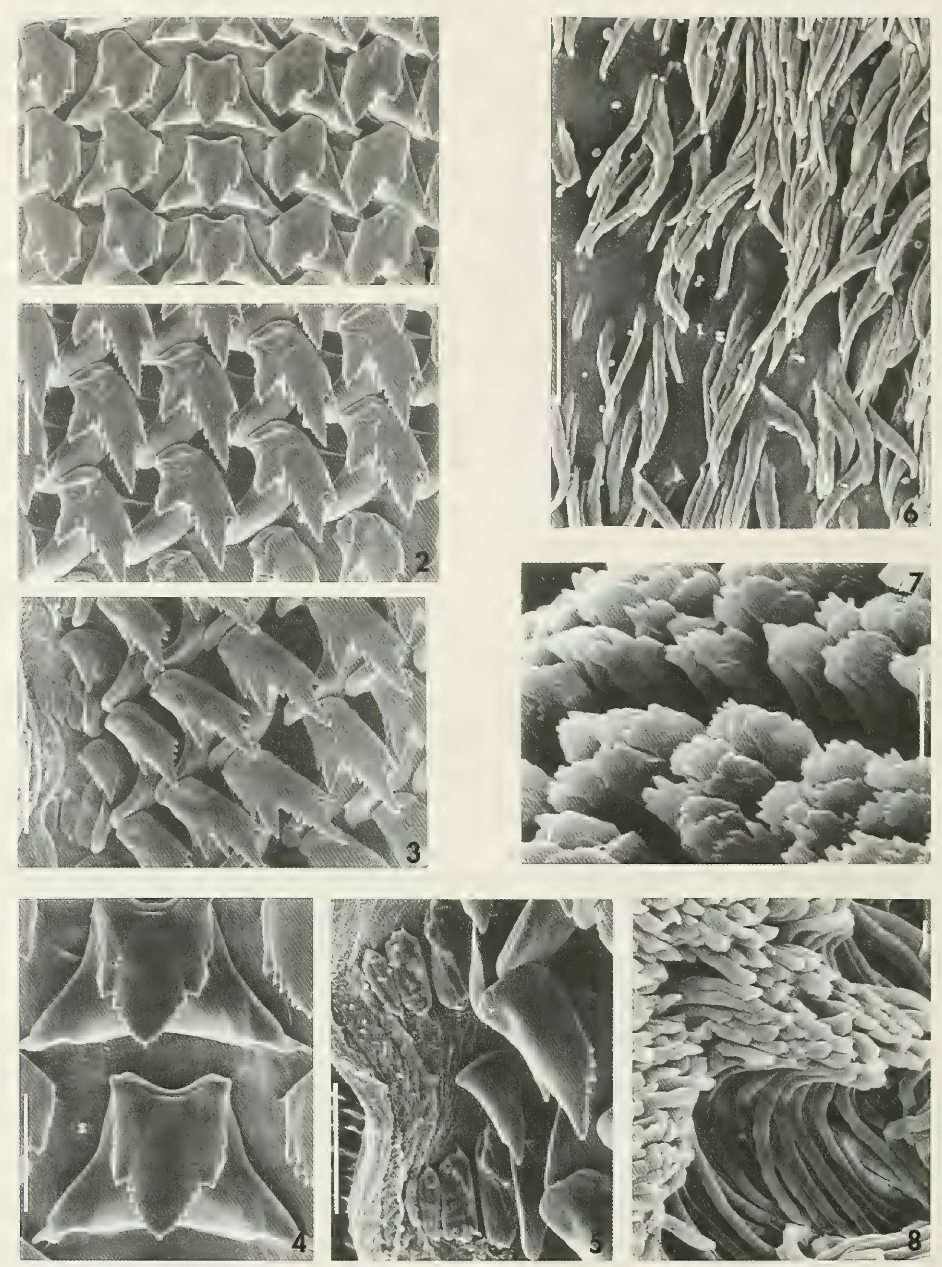
Aplysia gracilis Eales, 1960 was originally described from the Suez Canal as a new species, but some years latter the same author (EALES, 1979: 7) considered it as a juvenile stage of *A. fasciata*.

Material examined

- Spain: Cabo Peñas, Asturias (NW Spain), one specimen, 124 mm preserved lenght (Martínez coll., 1992); Eo estuary, Asturias, three specimens, more than 150 mm preserved lenght (Martínez coll., 1992).
- Italy: Fusaro lake, Naples gulf, one specimen, 80 mm preserved lenght (Martínez coll., 1993).
- Cape Verde: Matiota, San Vicente island, one specimen, 70 mm preserved lenght (Rolán coll., 1985); Tarrafal, Santiago Island, seven specimens more than 200 mm preserved lenght (Rolán coll., 1986).
- Mauritania: Nouackchot, ten specimens between 38-54 mm preserved lenght (MNHN, Gofas coll., 1986).
- Ghana: Miemia, one specimen, 90 mm preserved lenght (MNCN, 15.05/21416, Templado coll., 1993); Sekondi-Takoradi, one specimen, 40 mm preserved lenght; Pumpuni, one specimen, 37 mm preserved lenght (MNCN, 15.05/21414, Templado coll., 1993); Bushua, one specimen, 28 mm preserved lenght (MNCN, 15.05/21415, Templado coll., 1993). Two specimens without specified locality, 86 and 32 mm preserved lenght (NHM, 1958.1.9.1-2, Irvine leg.), both labelled as *Aplysia brasiliana*. Paratypes of *Aplysia winneba*: 4 specimens from Christiansbourg, near Accra, Ghana, between 50 and 60 mm preserved lenght (NHM 1957.6.18.4-7, R. Bassindale coll.). One of them dissected for anatomical study.
- Angola: Corimba and Cacuaco, Bengo province, six specimens between 70-103 mm preserved lenght (MNHN, Gofas coll., 1981).
- Saint Helena: one specimen, 105 mm preserved lenght (NHM, 1968.4.8.1, Mellis coll.), labelled as *Aplysia brasiliana*.

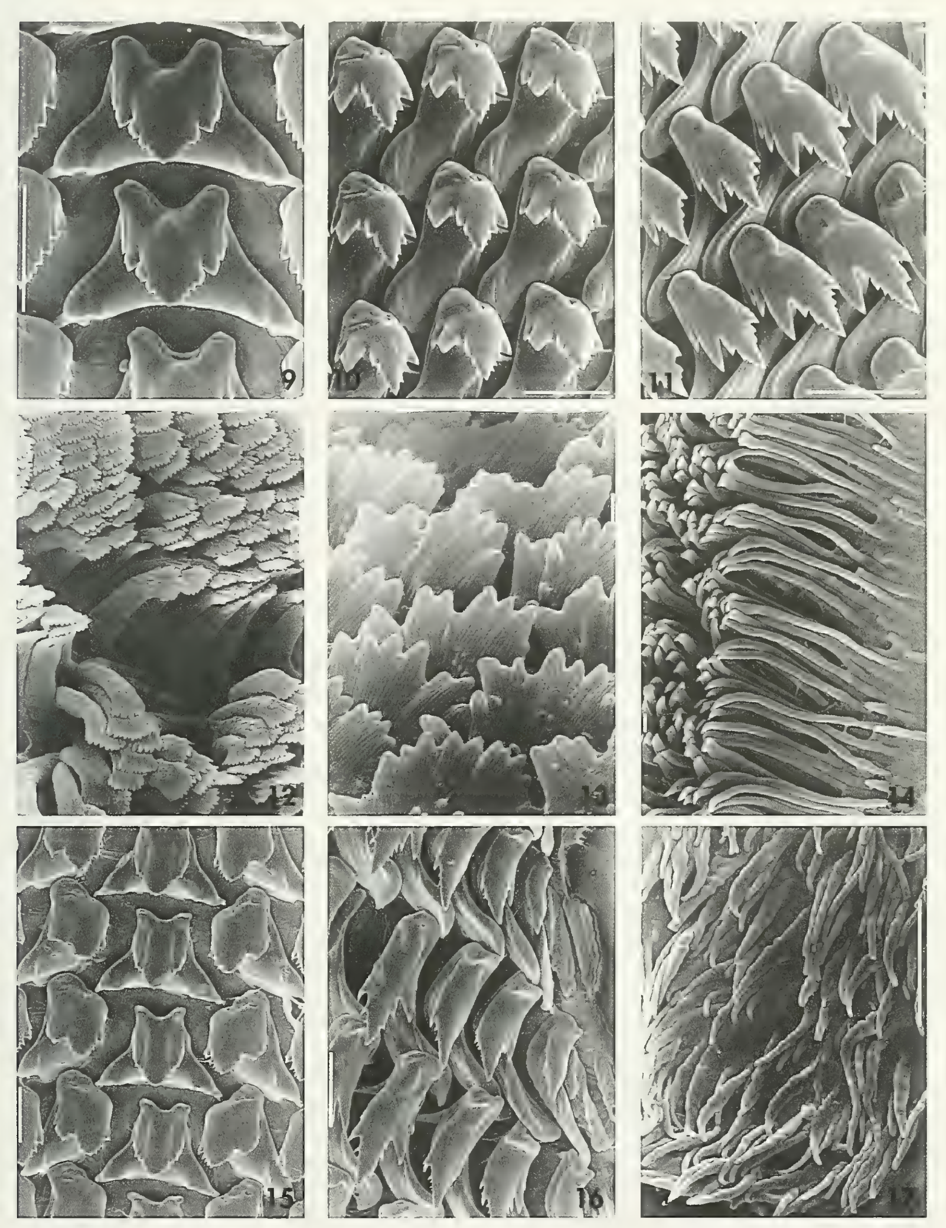
Original description of *Aplysia winneba*: EALES (1957a: 183) originally described *A. winneba* as follows: "Aplysias of moderate size, purplish black in colour, with vertical bands of dark and light on the inner sides of the parapodial edges. Highly mobile, with fimbriated cephalic tentacles, parapodia and anal siphon, moderately wide foot and short tail. Penis long and filiform. Mantle thin with a small tubular aperture. Purple glands present. Opaline gland compound, with a single conspicuous aperture".

Description of the *A. winneba* paratypes: According to the original description, the mantle has a small tubular aperture, whereas in the examined specimens of the paratypic series there is no such an aperture, but a minute papilla. In the dissected paratype, 60 mm long



Figures 1-8. Dissected paratype of *Aplysia winneba* (60 mm preserved lengh). 1: rachidian and first lateral teeth; 2: lateral teeth from sixth to ninth; 3: outermost lateral and marginal teeth; 4: detail of the rachidian tooth; 5: detail of the marginal teeth; 6: palatal teeth; 7: jaw elements; 8: jaw elements, near the masticatory edge. Scale bars, 1-6: 100 µm; 7, 8: 10 µm.

Figuras 1-8. Paratipo disecado de Aplysia winneba *(60 mm fijado). 1: diente raquídeo y primeros dientes laterales; 2: dientes laterales desde el 6º al 9º; 3: últimos dientes laterales y dientes marginales; 4: detalle del diente raquídeo; 5: detalle de los dientes marginales; 6: dientes palatales; 7: aspecto de los uncinos de la armadura labial; 8: los mismos, cerca del borde masticador. Escalas, 1-6: 100 µm; 7, 8: 10 µm.*



Figures 9-17. *Aplysia fasciata*. 9-14: Specimen from Ghana (40 mm preserved lenght). 9: detail of the rachidian tooth; 10: inner lateral teeth; 11: outer lateral teeth; 12: jaw elements; 13: a detail of jaw elements; 14: jaw elements, near the masticatory edge. 15-17: Specimen from Angola (70 mm preserved lenght). 15: rachidian and innermost lateral teeth; 16: last lateral and marginal teeth; 17: palatal teeth. Scale bars 9, 10, 11, 15-17: 100 µm; 12, 14: 10 µm; 13: 1 µm.

Figuras 9-17. Aplysia fasciata. *9-14: Ejemplar de Ghana (40 mm fijado). 9: detalle del diente raquídeo; 10: primeros dientes laterales; 11: últimos dientes laterales; 12: uncinos de la armadura labial; 13: detalle de los anteriores; 14: aspecto de los uncinos del borde masticador de la armadura labial. 15-17: Ejemplar de Angola (70 mm fijado). 15: diente raquídeo y primeros dientes laterales; 16: últimos dientes laterales y dientes marginales; 17: dientes palatales. Escalas 9, 10, 11, 15-17: 100 µm; 12, 14: 10 µm; 13: 1 µm.*

Table I. Comparative table of radular formulae of *Aplysia fasciata* specimens from different localities. (*) data from the dissected paratype of *Aplysia winneba* Eales; (**) data from the original description of *Aplysia winneba* Eales.
Tabla I. Tabla comparativa de las fórmulas radulares de ejemplares de Aplysia fasciata *procedentes de distintas localidades. (*) datos del paratipo disecado de* Aplysia winneba *Eales; (**) datos de la descripción original de* Aplysia winneba *Eales.*

Species	Locality	Formula	Animal lenght	Reference
A. fasciata	Angola	38 x 3.25.1.25.3	70 mm	this paper
A. fasciata	Angola	39 x 3.24.1.24.3	103 mm	this paper
A. fasciata	Ghana	37 x 4.18.1.18.4	40 mm	this paper
A. fasciata	Ghana	29 x 4.12.1.12.4	28 mm	this paper
A. winneba *	Ghana	39 x 4.24.1.24.4	60 mm	this paper
A. winneba **	Ghana	55 x 3.34.1.34.3	70 mm	Eales, 1957
A. fasciata	Mauritania	31 x 3.21.1.21.3	54 mm	this paper
A. fasciata	Cape Verde	49 x 4.23.1.23.4	70 mm	this paper
A. fasciata	Asturias (NW Spain)	50 x 3.33.1.33.3	125 mm	this paper

after fixation, the nervous system shows the cerebral ganglia completely fused together. The opaline gland is compound, resembling a bunch of grapes, well developed and with a single aperture.

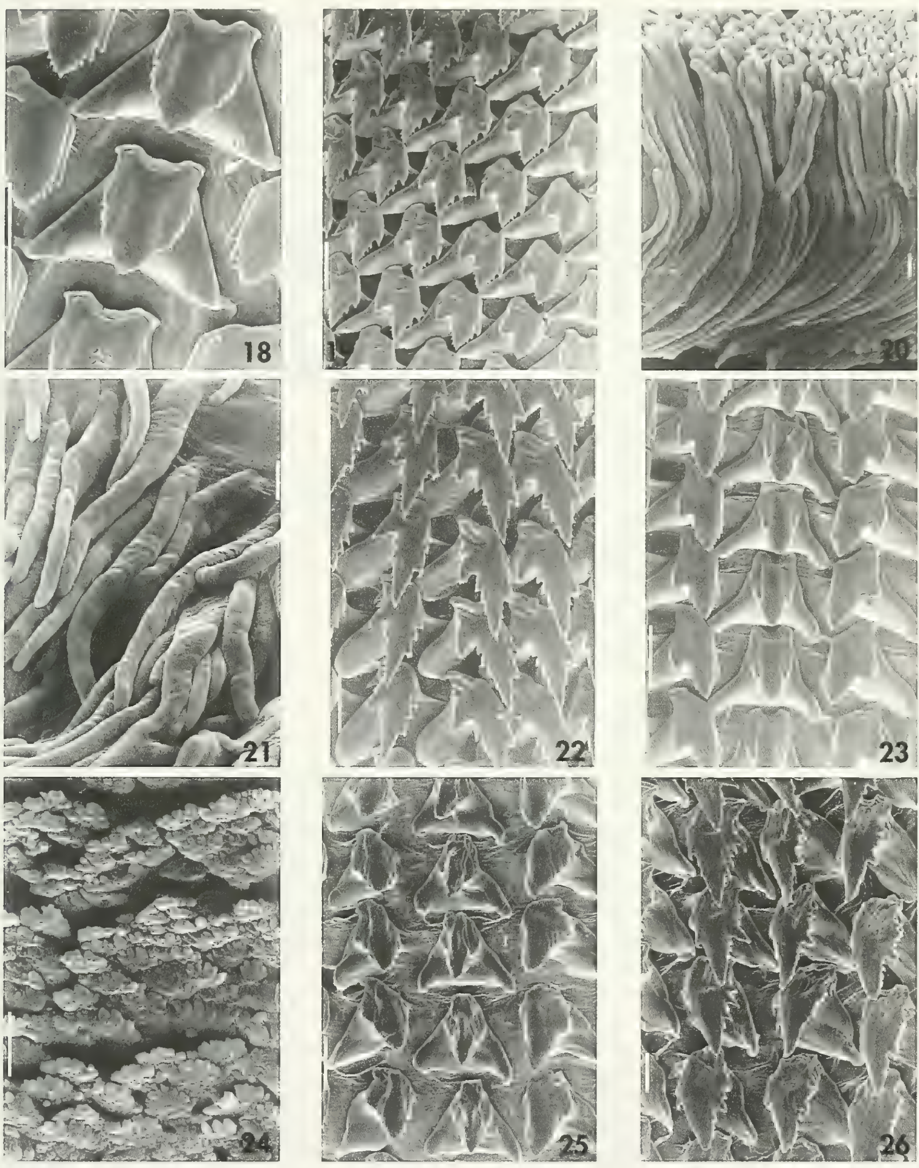
The radular formula is 39 x 4.24.1.24.4, and the SEM study shows a high rachidian tooth, with a denticulated central cusp and two secondary and smaller cusps on each side, the outermost less developed (Figs. 1, 4). The inner lateral teeth have a main denticulated cusp that becomes longer and narrower along the half-row (Figs. 1-3); near the base of this main cusp there are two outer secondary cusps (the first one well developed), and also an inner secondary cusp. The four outermost teeth are vestigial (Fig. 5).

The jaws are two simetrical plates provided with numerous elements, each one with 6-9 short conical extensions at their free edges (Fig. 7). Near the masticatory edge, the jaw elements are long and narrow, bent and eroded at the edges (Fig. 8). The palatal teeth are hook-shaped and laterally compressed, long and wide at the base, becoming narrower towards the free edge (Fig. 6).

In the genital tract there is a glandular area near the end of the distal hermaphroditic duct, in front of and behind the gametolitic gland stalk opening (Fig. 27). The penial sheath had two retractor muscles, and some others that anchor it to the body wall. The penis is filiform (Fig. 28). On the inner side of the penial sheath there is a small flap near the fundus.

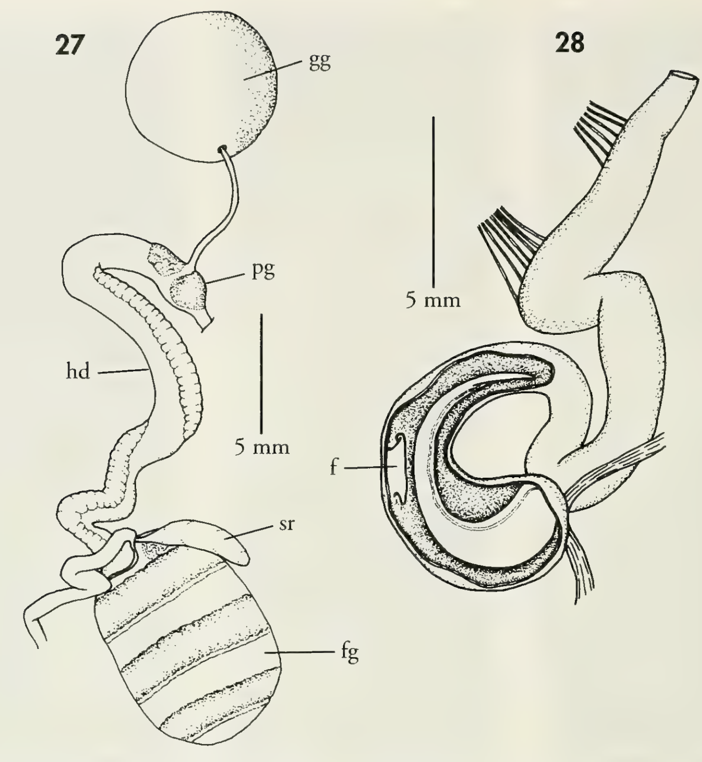
Description of the *Aplysia fasciata* material: Among all the examined material of *A. fasciata* only one specimen from Ghana has a small hole in the mantle, instead of a small papilla. The small preserved specimens from Ghana and Mauritania have the inner edge of the parapodial lobes with vertical bands of dark pigment, which are not visible in larger animals from other localities.

In all the dissected specimens, radular teeth show well developed and sharpened cusps. The rachidian tooth is wide at the base and it narrows towards the upper end. It has a central, denticulated cusp and two very small lateral cusps on each side (Figs. 9, 18). In larger specimens the rachidian tooth is higher and narrower, and the central cusp is longer (Figs. 15, 23, 25). Lateral teeth bearing a main, denticulated cusp that becomes longer along the half-row, having two (sometimes three) secondary cusps near the base, on the outer



Figures 18-26. *Aplysia fasciata*. 18-21: Specimen from Mauritania (45 mm preserved lenght). 18: detail of the rachidian tooth; 19: inner lateral teeth; 20: jaw elements, near the masticatory edge; 21: palatal teeth. 22, 23: Specimen from Naples (80 mm preserved lenght). 22: lateral teeth from 5th to 7th; 23: rachidian and innermost lateral teeth. 24-26: Specimen from NW Spain (more than 150 mm preserved lenght). 24: jaw elements. 25: rachidian and innermost lateral teeth; 26: lateral teeth, from 8th to 10th. Scale bars 18, 19, 22, 23, 25, 26: 100 µm; 20, 21, 24: 10 µm.

Figuras 18-26. Aplysia fasciata. *18-21: Ejemplar de Mauritania (45 mm fijado). 18: detalle del diente raquídeo; 19: primeros dientes laterales; 20: uncinos del borde masticador de la armadura labial; 21: dientes palatales. 22, 23: Ejemplar de Nápoles (80 mm fijado). 22: dientes laterales, del 5º al 7º; 23: diente raquídeo y primeros dientes laterales. 24-26: Ejemplar del noroeste de España (más de 150 mm fijado). 24: uncinos de la base de la armadura labial. 25: diente raquídeo y primeros dientes laterales; 26: dientes laterales, del 8º al 10º. Escalas 18, 19, 22, 23, 25, 26: 100 µm; 20, 21, 24: 10 µm.*

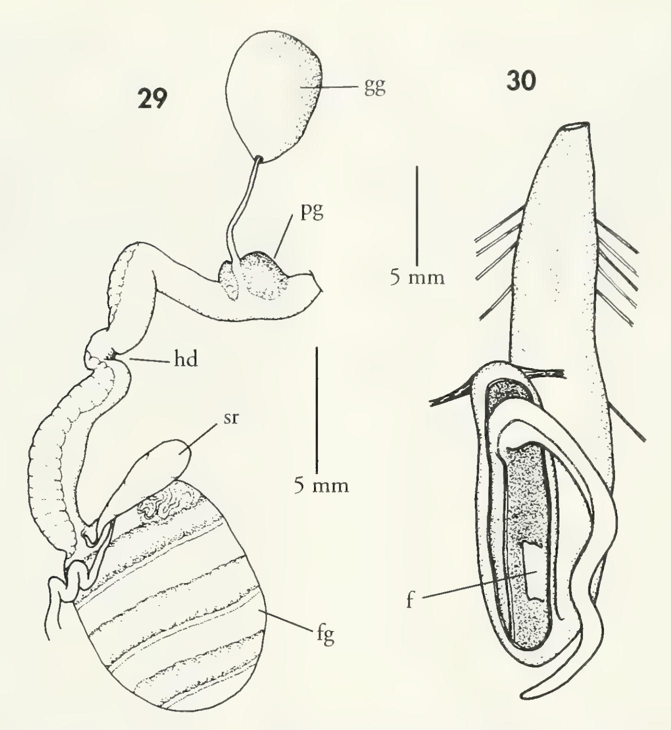


Figures 27, 28. Dissected paratype of *Aplysia winneba* (60 mm preserved lengh). 27: reproductive system; 28: opened penial sheath, showing the long and filiform penis, and the flap on the inner side of the penial sheath. Abbreviations. f: flap; fg: female glands; gg: gametolitic gland; hd: hermaphroditic duct; p: penis; pg: prostatic gland; sr: seminal receptacle.
Figuras 27, 28. Paratipo disecado de Aplysia winneba *(60 mm fijado). 27: aparato genital; 28: bolsa del pene abierta, mostrando el pene, largo y filiforme, y el pliegue del interior de la bolsa. Abreviaturas. f: pliegue; fg: glándulas femeninas; gg: glándula gametolítica; hd: conducto hermafrodita; p: pene; pg: glándula prostática; sr: receptáculo seminal.*

side, the first one well developed (Figs. 10, 11, 19, 22, 26). There is also a small secondary cusp on the inner side of the main cusp. About the four outermost teeth are vestigial (Fig. 16). Radular formulae for specimens from various localities are recorded in Table I; it shows that the number of teeth for each half-row is always less than 40.

Jaw elements are long and narrow (about 100 µm in a 40 mm preserved specimen) (Fig. 14). They have about 7-10 short conical extensions at their free edges (Figs. 12, 24) and, under high magnification, show longitudinal striae (Fig. 13). Towards the masticatory edge of the jaw plates these elements are eroded (Figs. 14, 20). Palatal teeth are long and hook-shaped (Figs. 17, 21), laterally compressed.

In the reproductive system there is a glandular area well visible as a widening of the distal hermaproditic duct, at the level of the gametolitic gland stalk opening (Fig. 29); The penis is long and filiform (Fig. 30). There is a small flap on the inner side of the penial sheath, that is always situated near the penial base, although its position can show some variation.



Figures 29, 30. Dissected specimen of *Aplysia fasciata* from Angola. 29: reproductive system; 30: opened penial sheath, showing the long and filiform penis, and the flap on the inner side of the penial sheath. Abbreviations as in Figures 27 and 28.

Figuras 29, 30. Ejemplar disecado de Aplysia fasciata *de Angola. 29: aparato genital; 30: bolsa del pene abierta, mostrando el pene, largo y filiforme y el pliegue del interior de la bolsa. Abreviaturas como en las Figuras 27 y 28.*

DISCUSSION

Aplysia fasciata is a well known species, whose most remarkable external features are the presence of two well developed parapodial lobes, widely separated anteriorly and posteriorly, and a mantle having a small hole or showing instead of this a minute papila; adults usually are dark in colour (velvety black), with red borders of the parapodia, cephalic tentacles and rhinophores (EALES, 1960; THOMPSON, 1976). Several anatomical studies have been published on this species. For instance RANG (1828: 55, pl. 6) described and figured very acurately the external morphology and the shell, and PILSBRY (1895: 72, pl. 33) figured the shell and the opaline gland (as *Tethys leporina*). EALES (1960: 316) described the radular morphology, and the reproductive system and the penial morphology have been described by THOMPSON AND BEBBINGTON (1969: 349).

As it has been previously commented, when EALES (1957a) described *Aplysia winneba*, she mentioned the structural resemblance between this species and *A. fasciata*; but in her opinion both differed "in shape, pigmentation, mode of contraction; in the width, toughness and frilled edges of the foot; in the size, height and fimbriation of the parapodia, and in the shell and radula". However, most of these characters (as the shape, pigmentation, size, width of the foot, etc.) are very variable with the state of preservation,

thus they have no taxonomic value when distinghishing between specimens of the two species.

EALES (1957a) provided a description of the colour based on some photographs of living animals as "purplish black in colour, with browner shades on the mantle". Although the typical coloration of *A. fasciata* is black with scarlet rims on the parapodia and tentacles, this pattern is normally present in the largest specimens, whereas smaller ones usually have a browner ground colour. The shell described by EALES (1957a) lacks a calcareous layer, but it is due to fixation.

Eales' description of the radula of *A. winneba* fits into the intraspecific variability of *A. fasciata*. Eales pointed out that both the rachidian tooth and the first lateral tooth have a rounded cusp; but in the examined paratype the cusps are more or less rounded only in the anterior half of the radula, because they are damaged by eating, which is very common within the genus *Aplysia*.

Comparison of SEM photographs of the radula and jaw elements of *A. fasciata* specimens from different localities and those of the paratype of *A. winneba* reveals an identical morphology in both groups of specimens.

According to THOMPSON AND BEBBINGTON (1969), the widening glandular area that may be discerned in gross dissections near the end of the distal hermaphroditic duct is the prostatic gland. In the penial sheath, the small flap is typical of *A. fasciata* and may act as a guide during mating, in THOMPSON' s opinion (1976).

Examination of several anatomical characters of the paratypes does not support the maintenance of *Aplysia winneba* Eales, 1957 as a different species and indicates that it is a synonym of *A. fasciata* Poiret, 1789. On the other hand a review of specimens from Ghana and Saint Helena that Eales identified as *Aplysia brasiliana* indicates that it was a missidentification, and that those specimens belong to the species *A. fasciata* (on the basis of their radular and penial morphology). In *Aplysia brasiliana* the penis is also long and filiform, but it widens considerably near the base and is flattened near the tip, and there is not a flap on the inner side of the penial sheath.

After this study, the known geographical range of *Aplysia fasciata* in the east Atlantic extends from the south west of England (GRIGG, 1949) and France (BEBBINGTON AND THOMPSON, 1968) to Angola and Saint Helena. New records in Mauritania and Saint Helena are given here. This species is also common in Mediterranean waters.

EALES (1979: 7) identified some specimens from Elat (Gulf of Aqaba, Red Sea) as *A. fasciata*, concluding that "this Mediterranean and eastern Atlantic species has extended its range southwards into the Indo-Pacific zone, and is the only member to the family to date to have done so". So, according to EALES (1979), *A. fasciata* is a lessepsian emigrant. Other species of *Aplysia* recorded at the Red Sea are *A. cornigera* Sowerby, 1869, *A. dactylomela* Rang, 1828, *A. oculifera* Adams and Reeve, 1850 and *A. parvula* Guilding in Mörch, 1863 (EALES, 1979; BARASH AND ZENZIPER, 1994), all them clearly different from *A. fasciata*. Nevertheless, the reference to *A. fasciata* in the Red Sea is doubtful, and the species was not included by BARASH AND ZENZIPER (1994) in their checklist of Opisthobranchs.

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Indo-Pacific dorid nudibranchs collected in Lebanon (eastern Mediterranean)

Nudibranquios doridáceos indo-pacíficos recolectados en el Líbano (Mediterráneo oriental)

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ABSTRACT

Plocamopherus ocellatus Rüppell and Leuckart, 1830, *Hypselodoris infucata* (Rüppell and Leuckart, 1830) and *Discodoris lilacina* (Gould, 1852) are reported from Lebanon for the first time. This is also the first confirmed report, based on anatomical examination, of these three species in the eastern Mediterranean. All specimens examined were fully mature and it is very likely that these three species have stable and reproductively active populations in the Mediterranean.

RESUMEN

Plocamopherus ocellatus Rüppell y Leuckart, 1830, *Hypselodoris infucata* (Rüppell y Leuckart, 1830) y *Discodoris lilacina* (Gould, 1852) se citan en el Líbano por primera vez. Además, estas son las primeras citas confirmadas con estudios anatómicos de estas tres especies en el Mediterráneo oriental. Todos los ejemplares examinados eran completamente maduros, por lo que es muy probable que estas tres especies tengan poblaciones estables y reproductivamente activas en el Mediterráneo.

KEY WORDS: Lessepsian immigrants, Nudibranchia, Doridoidea, *Plocamopherus ocellatus, Hypselodoris infucata, Discodoris lilacina*, Lebanon, eastern Mediterranean.
PALABRAS CLAVE: Inmigrantes Lessepsianos, Nudibranchia, Doridoidea, *Plocamopherus ocellatus, Hypselodoris infucata, Discodoris lilacina*, Líbano, Mediterráneo oriental.

INTRODUCTION

Since the early eighties, a small but steadily increasing number of Indo-Pacific opisthobranch species have been reported from the Mediterranean Sea. These Lessepsian immigrants have been mostly found in the coasts of Israel, Turkey, and Lebanon, in the eastern Mediterranean (BARASH AND DANIN, 1977; MIENIS AND GAT, 1981; GAT AND MIENIS, 1981; BARASH AND DANIN, 1982; 1986; BOGI AND KHAIRALLAH, 1987; AARTSEN, CARROZZA AND LINDNER, 1990; BOGI AND GIANNINI, 1990; GAT, 1993; ÇEVIK AND ÖZTÜRK, 2001). Some of

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these records are unconfirmed due to the absence of anatomical studies or voucher specimens available in scientific institutions.

The present paper deals with a small collection of opisthobranchs collected in Lebanon by Ghazi Bitar and Helmut Zibrowius, and constitutes the first confirmed report of some Lessepsian immigrants. These opisthobranchs were made available to us by the collectors including brief descriptions of the external color, but without photographs or drawings of the living animals, so identifications were based on these notes and anatomical examination of preserved specimens. Illustrations of the external morphology of the preserved specimens have not been included. The material examined is deposited at the Natural History Museum of Los Angeles County (LACM) and the Museo Nacional de Ciencias Naturales, Madrid (MNCN).

SPECIES DESCRIPTIONS

Family Triophidae Odhner, 1941
Genus *Plocamopherus* Leuckart *in* Rüppell, 1828

Plocamopherus ocellatus Rüppell and Leuckart, 1830 (Figs. 1-2A)

Material examined: Chak El Hatab, between Hannouch and Selaata, Lebanon, 5 m depth, 4 June 2000, 1 specimen 22 mm preserved length (LACM 152716). Raoucheh, Lebanon, 7 m depth, 19 September 2002, 2 specimens 31 mm and 20 mm preserved length (MNCN 15.05/46581).

Description: Body elongate, with the foot extending far beyond the posterior end of the notum. Dorsal surface of the posterior end of the foot with a high irregular fin-like protuberance. Velum with 17 ramified appendages. On each side of the body there are two ramified lateral papillae anterior to the gill and two clusters of 2-3 knob-like organs posterior to the gill. Gill composed of five tripinnate branchial leaves. Rhinophores with 28 lamellae. Background color black with several large, irregular reddish spots.

Radular formula 16 x 11.3.1.3.11. There is a broad rachidian plate, which is traversed by a strong furrow and divided into several elongate tuberculate plates (Fig. 1A). The 3 innermost lateral teeth are hook shaped having a secondary cusp, and are similar in length (Fig. 1B). The 11 outermost lateral teeth are rectangular and decrease in size towards the margin of the radula. Jaws composed of numerous simple elements (Fig. 1C).

Reproductive system triaulic. Ampulla convoluted, branching into a short oviduct and the prostate (Fig. 2A). Oviduct entering the female gland mass near its opening. Prostate large and flat; connecting with the deferent duct, which expands again into the ejaculatory portion. Muscular deferent duct and vagina opening into a common atrium. Vagina long and straight. At its proximal end the vagina joins the bursa copulatrix. From the bursa copulatrix leads another duct connecting with the uterine duct and the seminal receptacle. Bursa copulatrix oval in shape, about twenty times as large as the seminal receptacle.

Remarks: *Plocamopherus ocellatus* is a poorly known Red Sea species characterized by its external dark coloration with reddish or orange spots (Eliot, 1908). Eliot's (1908) is the only record of this species from the Red Sea after its original description by Rüppell and Leuckart (1828-30) [1830]. The features of our specimens agree with the original description and redescription, and there is no doubt they belong to the same species.

This species was recorded from the Mediterranean for the first time by Barash and Danin (1982) in Nizzanim, Israel. The present study constitutes the second Mediterranean record, based on three specimens.

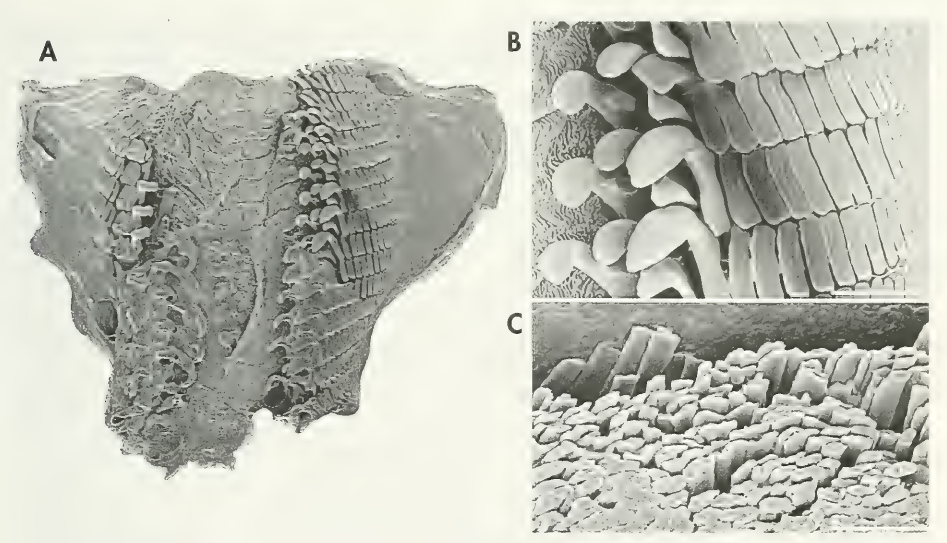


Figure 1. Scanning electron micrographs of the radula and jaws of *Plocamopherus ocellatus* Rüppell and Leuckart, 1830 (LACM 152716). A: general view of the radula; B: detail of a half-row; C: jaw elements. Scale bars, A: 1 mm; B, C: 200 μm.

Figura 1. Fotografías de microscopio electrónico de barrido de la rádula y mandibulas de Plocamopherus ocellatus *Rüppell y Leuckart, 1830 (LACM 152716). A: vista general de la rádula; B: detalle de una semihilera; C: elementos de la mandíbula. Escalas, A: 1 mm; B, C: 200 µm.*

Family CHROMODORIDIDAE Bergh, 1891
Genus *Hypselodoris* Stimpson, 1855

Hypselodoris infucata (Rüppell and Leuckart, 1830) (Figs. 2B, 3)

Material examined (localities in South to North order): Beyrouth Harbor, Lebanon, 2 June 2000, 3-8 m, 36 specimens 13-24 mm preserved length (LACM 152756) and 27 specimens 11-31 mm preserved length (MNCN 15.05/45958). Jbaïl, Lebanon, 17 October 1999, harbour entrance, 2-3 m, 1 specimen (MNCN 15.05/45959). Selaata, Lebanon, 2 May 2001, 1 specimen 8 mm preserved length (LACM 152757). El Heri, Lebanon, 2-3 m depth, 3 June 2000, 2 specimens 7-10 mm preserved length (LACM 152758). Ramkine Island, off Tripoli, Lebanon, 31 May 2000, 4 specimens 12-22 mm preserved length (LACM 152755).

Description: Body elongate and relatively high in profile, with the foot extending far beyond the posterior end of the notum. Dorsum smooth. Gill composed of 11 unipinnate branchial leaves and rhinophores with 15 lamellae in a 20 mm preserved length specimen (LACM 152756). Background colour blue or greenish blue. There may be darker and lighter areas irregularly distributed on the dorsum. In some specimens the blue color fades to paler blue in the middle of the dorsum. Dark blue and yellow spots scattered over the entire dorsum.

Radular formula 54 x 62.0.62. Rachidian teeth absent. Innermost lateral teeth with two large cusps and a shorter denticle on the inner side of the cusp (Fig. 3A). Remaining lateral teeth hook-shaped, with two cusps and lacking denticles on both sides. Outer laterals are short, having 1-8 denticles situated under the second cusp (Fig. 3B). Jaws composed of numerous, simple elements.

Reproductive system triaulic. Ampulla elongated, branching into a short oviduct and the prostate (Fig. 2B). Oviduct entering the female gland mass

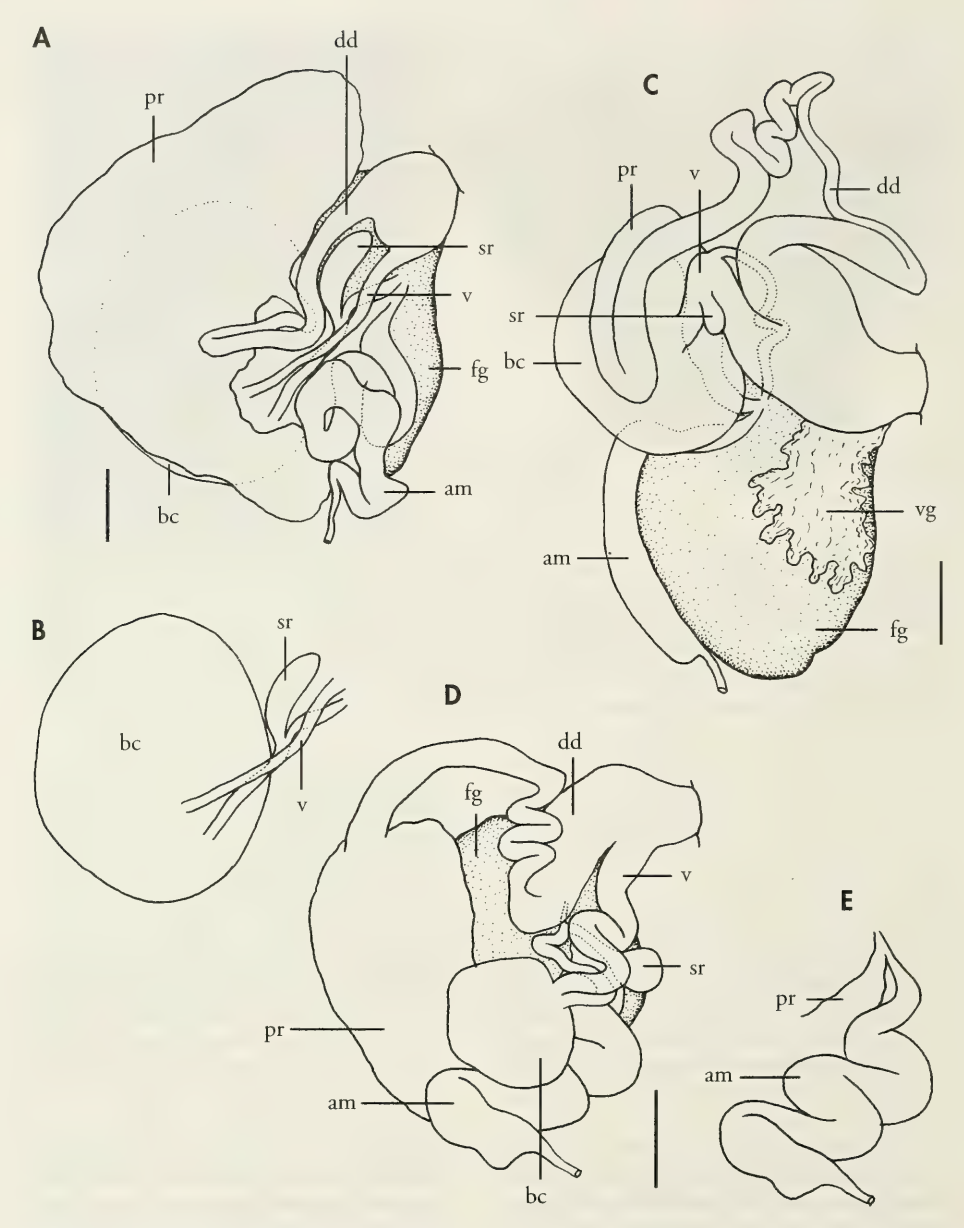


Figure 2. Reproductive systems (scale bars, 1 mm). A, B: *Plocamopherus ocellatus* Rüppell and Leuckart, 1830 (LACM 152716); C: *Hypselodoris infucata* (Rüppell and Leuckart, 1830) (LACM 152755); D, E: *Discodoris lilacina* (Gould, 1852) (LACM 152717). Abbreviations, am: ampulla; bc: bursa copulatrix; dd: deferent duct; fg: female glands; pr: prostate; sr: seminal receptacle; v: vagina; vg: vestibular gland.

Figura 2. Aparatos reproductores (escalas, 1 mm). A, B: Plocamopherus ocellatus *Rüppell y Leuckart, 1830 (LACM 152716); C:* Hypselodoris infucata *(Rüppell and Leuckart, 1830) (LACM 152755); D, E:* Discodoris lilacina *(Gould, 1852) (LACM 152717). Abreviaturas, am: ampolla; bc: bolsa copulatriz; dd: conducto deferente; fg: glándulas femeninas; pr: próstata; sr: receptáculo seminal; v: vagina; vg: glándula vestibular.*



Figure 3. Scanning electron micrographs of the radula of *Hypselodoris infucata* (Rüppell and Leuckart, 1830). A: Inner lateral teeth; B: Outer lateral teeth. Scale bars, 20 μm.
Figura 3. Fotografías de microscopio electrónico de barrido de la rádula de Hypselodoris infucata *(Rüppell and Leuckart, 1830). A: Dientes internos; B: Dientes externos. Escalas, 20 μm.*

near the center of the mass. Prostate long and tubular; connecting with a thinner duct that expands again into the ejaculatory portion of the deferent duct. Muscular deferent duct and vagina opening into a common atrium. Vagina long and folded. At its proximal end the vagina joins the bursa copulatrix. At mid-length the uterine duct and the seminal receptacle connect with the vagina. Bursa copulatrix oval in shape, about thirty times as large as the seminal receptacle.

Remarks: The material here examined is anatomically identical to Indo-Pacific specimens of *Hypselodoris infucata* recently re-described by JOHNSON AND VALDÉS (2001).

Hypselodoris infucata is a well-known Indo-Pacific immigrant in the Mediterranean. The first Mediterranean record of this species was published by BARASH AND DANIN (1974) under the name *Glossodoris runcinata*. There are two subsequent records from Israel by GAT AND MIENIS (1981) and MIENIS AND GAT (1981). More recently ÇEVIK AND ÖZTÜRK (2001) reported *H. infucata* from southern Turkey; according to these authors *H. infucata* reached the coast of Turkey following the northbound current parallel to the coast of Palestine, Israel, Lebanon and Syria.

All the specimens examined were sexually mature and most likely reproductively active. The large number of specimens collected also indicates that this species has stable populations in the eastern Mediterranean, as suggested by BARASH AND DANIN (1986). In Beyrouth harbour the population is thriving in a highly polluted environment.

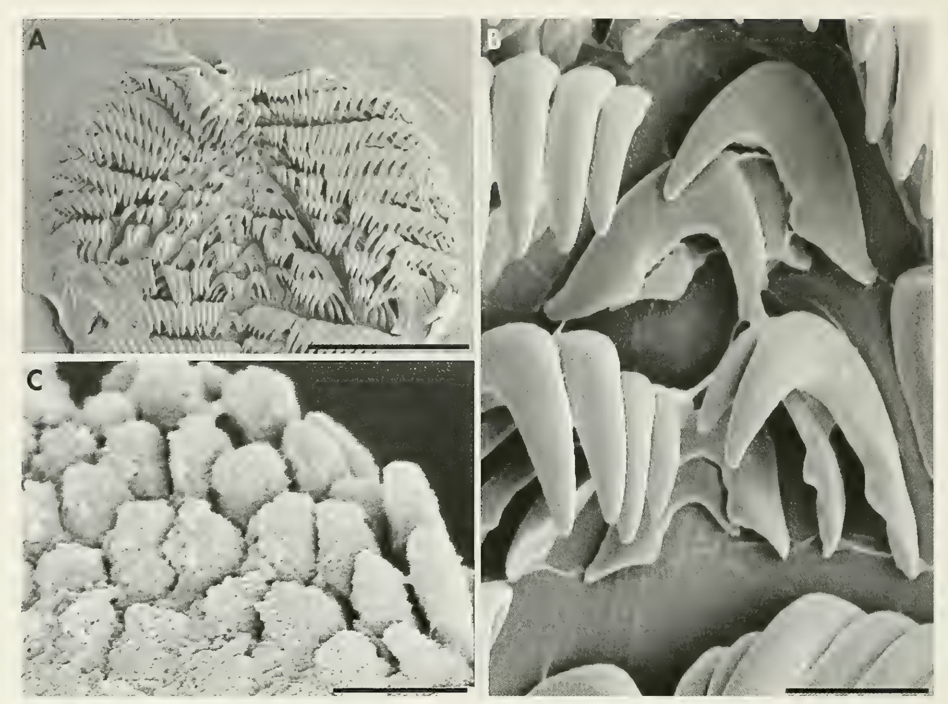


Figure 4. Scanning electron micrographs of the radula and jaws of *Discodoris lilacina* (Gould, 1852) (LACM 152717). A: general view of the radula; B: inner lateral teeth; C: jaw elements. Scale bars, A: 500 µm; B: 50 µm; C: 10 µm.

Figura 4. Fotografías de microscopio electrónico de barrido de la rádula y mandíbulas de Discodoris lilacina *(Gould, 1852) (LACM 152717). A: vista general de la rádula; B: dientes internos; C: elementos de las mandíbulas. Escalas, A: 500 µm; B: 50 µm; C: 10 µm.*

Family Discodorididae Bergh, 1891
Genus *Discodoris* Bergh, 1877

Discodoris lilacina (Gould, 1852) (Figs. 2C-D, 4)

Material examined: El Heri, Lebanon, 2-3 m depth, 3 June 2000, 1 specimen 23 mm preserved length (LACM 152717).

Description: Body flat, oval, with the posterior end of the foot covered by the notum. Dorsum covered by numerous, small conical tubercles, which are larger near the central area. Gill composed of 9 tripinnate brachial leaves. Rhinophores with 12 lamellae. The single specimen was preserved so information on the color of the living animal is not available. The preserved specimen is brownish with several rounded or oval dark brown spots of different sizes, being larger in the central region of the dorsum. Along the innermost sides of the mantle margin there are two lines of large, oval, black spots. Ventrally, the anterior border of the foot is grooved and notched. The ventral side of the foot and mantle margin are covered with numerous brownish spots of various sizes.

Radular formula 20 x 22.0.22. Inner and mid-lateral teeth hamate (Fig. 4A), with a single cusp and no denticles (Fig.

4B). Outermost teeth with an elongate cusp and also lacking denticles. Jaw composed of several small, irregular elements (Fig. 4C).

Reproductive system triaulic. Ampulla convoluted, branching into a short oviduct and the prostate (Fig. 2D). Oviduct entering the female gland mass near its opening (Fig. 2C). Prostate large and flat, with two distinct portions. The prostate connects with a thin duct that expands again into the ejaculatory portion of the deferent duct. Muscular deferent duct and vagina opening into a common atrium. Vagina long and convoluted. At its proximal end the vagina joins the bursa copulatrix. From the bursa copulatrix leads another duct connecting with the uterine duct and the seminal receptacle. Bursa copulatrix oval in shape, about ten times as large as the seminal receptacle.

Remarks: This is a widespread Indo-Pacific species collected in several localities from the Red Sea to Hawaii (see EDMUNDS, 1971), in most cases under the name *Discodoris fragilis* (Alder and Hancock, 1864). *Discodoris fragilis* is currently regarded as a syonym of *D. lilacina* (RUDMAN, 1999). The reproductive anatomy and radula of the Indo-Pacific specimens studied by EDMUNDS (1971) and KAY AND YOUNG (1961), are identical to those of our material, and there is no doubt about the identity of the Lebanese specimen.

BARASH AND DANIN (1977) cited *Discodoris lilacina* from Israel for the first time (as *D. concinna*). It is most likely that the specimen studied by Barash and Danin belongs to the same species as our material from Lebanon, but their record is unverifiable due to the absence of anatomical studies. The present paper is the first confirmed Mediterranean record for *D. lilacina*.

Records of *Discodoris fragilis* from the Canary Islands by ORTEA, BACALLADO AND PÉREZ-SÁNCHEZ (1981) and Madeira by WIRTZ (1995) belong to *Discodoris confusa* Ballesteros, Llera and Ortea, 1985, a species similar in external morphology (see BALLESTEROS, LLERA AND ORTEA, 1985 and WIRTZ , 1999).

CONCLUSIONS

Three other Lessepsian opisthobranchs have been recorded from Lebanon by BOGI AND KHAIRALLAH (1987) and BOGI AND GIANNINI (1990), all of them belonging to the Cephalaspidea: *Pyrunculus fourieri* (Audouin, 1826) (as *Retusa*), *Cylichnina girardi* (Audouin, 1826), and *Acteocina mucronata* (Philippi, 1849).

This is the first confirmed record in the Mediterranean of *Plocamopherus ocellatus* Rüppell and Leuckart, 1830, *Hypselodoris infucata* (Rüppell and Leuckart, 1830) and *Discodoris lilacina* (Gould, 1852) based on anatomical examination. It also constitutes the first anatomical study of *Plocamopherus ocellatus*, which was only known from external descriptions (Rüppell and Leuckart, 1828-30; Eliot, 1908). All specimens examined were fully mature and it is very likely that these three species have stable and reproductively active populations in the Mediterranean.

The present paper is a contribution to the atlas of exotic mollusks introduced in the Mediterranean, which is now ready for publication (ZENETOS, GOFAS, RUSSO AND TEMPLADO, in press), and it will include full color figures of the external morphology of all species. An electronic version of the atlas is currently available in the web site of the CIESM (International Commission for the Scientific Exploration of the Mediterranean Sea): http://www.ciesm.org/atlas.

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Toxic effects of latex of *Croton tiglium* on *Lymnaea acuminata* and *Channa punctatus*

Efectos tóxicos del latex de *Croton tiglium* sobre *Lymnaea acuminata* y *Channa punctatus*

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ABSTRACT

The aqueous latex extracts of *Croton tiglium* Linn. plant belonging to family Euphorbiaceae, was found to have strong molluscicidal activity against freshwater snail *Lymnaea* (*Radix*) *acuminata* Lamarck. Exposure of sub-lethal doses of latex extracts of this plant on snail *Lymnaea* (*Radix*) *acuminata* Lamarck over 24h or 96h caused significant change in carbohydrates and nitrogenous metabolism in nervous, hepatopancreas and ovotestis tissue.

Non-target fish *Channa punctatus* (Bloch) (Channidae [Ophicephalidae]) (which shares the habitat with these snails) was also exposed to sub-lethal doses for 96h exposure periods for measuring its potential, the environmental toxicity (if any). Sub-lethal exposure of fish shows significant alteration in carbohydrate and nitrogenous metabolism in muscle, liver and gonadal tissues. Withdrawal study also shows that there is a partial recovery in snail's tissues but nearly complete recovery in fish tissues after 7^{th} day of the withdrawal of treatment, which supports the view that plant products are safer in use as molluscicides than synthetic pesticides.

RESUMEN

Los extractos acuosos del latex de *Croton tiglium* Linn., de la familia Euphorbiaceae, tienen fuertes efectos molusquicidas sobre *Lymnaea (Radix) acuminata* Lamarck. La exposición a dosis subletales de dicho latex durante 24 o 96 horas produjo un significativo cambio en el metabolismo de los carbohidratos y del nitrógeno en el tejido nervioso, hepatopáncreas y ovotestis.

El pez *Channa punctatus* (Bloch) (Channidae [Ophicephalidae]) (que comparte hábitat con estos moluscos) también se expuso a dosis subletales durante el mismo periodo, con el fin de comprobar el potencial tóxico del extracto. Dicha exposición mostró una alteración significativa del metabolismo de carbohidratos y nitrógeno en los tejidos muscular, hepático y gonadal. También se comprobo que existe una recuperación parcial en los tejidos del molusco y una casi total recuperación en los del pez tras el séptimo día después de abandonado el tratamiento, lo que apoya la visión de que los productos procedentes de plantas son más seguros como molusquicidas que los pesticidas sintéticos.

KEY WORDS: *Channa punctatus*, *Croton tiglium*, metabolism, *Lymnaea acuminata*.
PALABRAS CLAVE: *Channa punctatus*, *Croton tiglium*, metabolism, *Lymnaea acuminata*.

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INTRODUCTION

Snails of the genus *Lymnaea* (*Radix*) and *Indoplanorbis* Deshayes are the hosts in the life cycle of the liver fluke (genus *Fasciola* Cobbold), which is responsible for fascioliasis, a disease affecting cattle and live stock population of Northern part of India (Singh and Agarwal, 1981). Control of harmful freshwater snails through synthetic pesticides has been reviewed in detail by various workers (Agarwal and Singh, 1988; Singh and Agarwal, 1990, 1993, 1995; Singh, Singh, Mishra and Agarwal, 1996). With growing awareness of environmental pollution caused by synthetic molluscicides (Ritchie, 1973; Christie, Prentice, Upatham and Banish, 1978; Cardarelli, 1974; Duncan, 1974; Srivastava and Singh, 2001), efforts are being made to find out molluscicides of plant origin. Being the product of biosynthesis, they are highly toxic and easily biodegradable in environment (Marston and Hostettman, 1987; Singh and Agarwal, 1992, 1993; Singh *et al.*, 1996). Earlier studies indicate that the Euphorbiales have potent molluscicidal activity against the freshwater snails *Lymnaea* (*Radix*) *acuminata* Lamarck and *Indoplanorbis exustus* Deshayes (Singh and Agarwal, 1988, 1990, 1992, 1995; Yadav and Singh, 2001). But little work has been done on their mode of action and their environmental impact on non-target organism.

The aim of this study is to measure the effects of sub-lethal exposure to aqueous extracts of latex of *Croton tiglium* Linn. on different biochemical parameters of freshwater target snail *Lymnaea* (*Radix*) *acuminata* Lamarck and non-target fish *Channa punctatus* (Bloch) (Channidae [Ophicephalidae]). *Channa punctatus* is a freshwater common fish of Indian captured fishery and share the habitat with the snail *Lymnaea acuminata*.

MATERIALS AND METHODS

Latex of *Croton tiglium* Linn. (Family Euphorbiaceae) plant was collected from Botanical garden of D.D.U, Gorakhpur University Gorakhpur India. White latex produced by this plant was drained in to glass beakers by cutting the stem apices and lyophilised at –40°C and the lyophilized dry powder was used for further study. The wet weight of 1 ml latex was 800 mg and dry weight (Lyophilised at –40°C) was 300 mg.

Adult *Lymnaea acuminata* (2.6±0.3 cm in shell height) and freshwater fish *Channa punctatus* (10.5±0.9 cm in length) were collected from Ramgarh Lake of Gorakhpur district, and mantained in plastic tank for acclimatization to laboratory conditions. The acclimatized animals were treated with latex of *Croton tiglium* Linn. according to the method of Singh and AGarwal (1988). The experimental animals were treated with sub-lethal doses (40% and 80% of LC_{50}) of the latices of *Croton tiglium* Linn. for 24h or 96h exposure periods. Six aquaria were set up for each dose and each aquarium contained either 30 snails or 10 fishes in 6L dechlorinated tap water.

The LC_{50} of aqueous latex extracts of *Croton tiglium* Linn. against snail *Lymnaea acuminata* was 0.060 mg/L and 0.014 mg/L for 24h and 96h, respectively (Yadav and Singh, 2001).

After completion of treatment the test animals were removed from the aquaria and washed with water. The nervous, hepatopancreas and ovotestis of *Lymnaea acuminata* and muscle, liver and gonadal tissue of *Channa punctatus* were excised and used for biochemical analysis. Control animals were held in similar conditions without any treatment.

In order to see the effect of withdrawal from treatment, the snails were first exposed to 80% of LC_{50} for 96h exposure periods and fishes were treated with 80% of LC_{50} (24h) for 96h exposure periods, following which snails and fishes were transfer to latex free water. This water was changed every 24h for the next seven days, after which biochemical parameters were estimated in different tissues. Each experiment was replicated at least six times and the values have been expressed as mean ±SE of six replicates. Student's 't' test

and analysis of variance were applied to locate significant changes (SOKAL AND ROHLF, 1973).

BIOCHEMICAL ESTIMATIONS

Protein: Protein levels were estimated according to the method of LOWRY, ROSENBROUGH, FARR AND RANDALL (1951) using bovine serum albumin as standard. Homogenates (5mg/ml, w/v) were prepared in 10%TCA.

Total free amino acids: Estimation of total free amino acid was made according to the method of SPICES (1957). Homogenates (10mg/ml, w/v) were prepared in 95% ethanol, centrifuged at 6000 xg and used for amino acid estimation.

Nucleic acids: Estimation of DNA and RNA was performed, by methods of SCHNEIDER (1957) using diphenylamine and orcinol reagents, respectively. Homogenates (1 mg/ml, w/v) were prepared in 5% TCA at 90^{0}C, centrifuged at 5000 g for 20 min and supernatant was prepared used for estimation. Both DNA and RNA have been expressed as mg/mg tissue.

Glycogen: Glycogen was estimated by the Anthrone method of VAN DER VIES (1954) as modified by MAHENDRU AND AGARWAL (1982) for snails. In present experiment 50 mg of tissue was homogenised with 5ml of cold 5%TCA. The homogenate were filtered and 1.0 ml of filtrate was used for assay.

Pyruvate: Pyruvate level was measured according to FRIEDEMANN AND HAUGEN (1943). Homogenate (50 mg/ml, w/v) was prepared in 10% TCA. Sodium pyruvate was taken as standard.

Lactate: Lactate was estimated according to BARKER AND SUMMERSON (1941), modified by HUCKABEE (1961). Homogenate (50 mg/ml, w/v) was prepared in 10% cold TCA. Sodium lactate was taken as standard.

Protease: Protease activity was estimated by the method of MOORE AND STEIN (1954). Homogenate (50 mg/ml, w/v) was prepared in cold distilled water. Optical density was measured at 570 nm. The enzyme activity was expressed in µmol of tyrosine equivalent/mg protein/h.

Acid and alkaline phosphatase: Activities of acid and alkaline phosphatase were measured by the method of BERGMEYER (1967) and modified by SINGH AND AGARWAL, (1983). Tissue homogenate (2% w/v) were prepared in ice cold 0.9% saline and centrifuged at 5000xg at 0∞C for 15 min. Optical density was measured at 420 nm against a blank, prepared simultaneously. The enzyme activity has been expressed as amount of p-nitrophenol formed/30min/mg protein in supernatant.

Lactic dehydrogenase: Lactic dehydrogenase (LDH) activity was measured according to the method of ANONYMOUS (1984). Homogenates (50 mg/ml, w/v) were prepared in 1 ml of 0.1 M phosphate buffer, pH 7.5 for 5 min in an ice bath. Enzyme activity has been expressed as nanomol of pyruvate reduced/min/mg protein.

Succinic dehydrogenase: Succinic dehydrogenase activity was measured by the method of ARRIGONI AND SINGER (1962). Homogenate (50 mg/ml, w/v) was prepared in 1 ml of 0.5M potassium phosphate buffer, pH 7.6 for 5 min in an ice bath. Optical density was measured at 600nm. Enzyme activity has been expressed as µmol dye reduced/min/mg protein.

Cytochrome oxidase: Cytochrome oxidase activity was measured according to the method of COOPERSTEIN AND LAZAROW (1951). Homogenates (50 mg/ml, w/v) were prepared in 1 ml of 0.33 M phosphate buffer (pH 7.4) for 5 min in ice bath. Enzyme activity has been expressed in arbitrary units/min/mg of proteins.

Acetylcholinesterase: Acetylcholinesterase was estimated by the method of ELLMAN, COURTNEY, ANDRES AND FEATHERSTONE., (1961) as adapted by SINGH AND AGARWAL (1982) for snail tissue. Homogenates (50 mg/ml, w/v) were prepared in 0.1 M phosphate buffer in ice bath. Optical density was measured at 412 nm at 25°C. Enzyme activity

expressed in µmol 'SH' hydrolysed/min/mg protein.

RESULTS

Effect on freshwater target snail: Data of sub-lethal (40% and 80% of LC_{50}) exposure of freshwater snail *Lymnaea acuminata* against aqueous extracts of latex of *Croton tiglium* are given in Table I-IV. Exposure of snails to 40% and 80% of LC_{50} of aqueous extracts of latex of *Croton tiglium* for 24h or 96h caused significant alterations in nitrogenous and carbohydrate metabolism in different tissues of the freshwater snail *Lymnaea acuminata*.

Effects on nitrogenous metabolism: Total protein and nucleic acids (DNA and RNA) levels were significantly reduced, while free amino acid level was significantly enhanced after the exposure to sub-lethal doses in all the body tissues. Acid and alkaline phosphatase activities were significantly reduced, while protease activity was increased after the exposure.

Total protein levels were reduced to 39%, 45% and 36% of controls after exposure to 80% of LC_{50} (96h) of aqueous latex extracts respectively in the nervous, hepatopancreas and ovotestis tissue of *Lymnaea acuminata*, respectively. DNA level was reduced to 36%, 45% and 28% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts in nervous, hepatopancreas and ovotestis, respectively. RNA level was reduced to 42%, 48% and 34% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis of snail. Total free amino acid levels were induced to 167%, 140% and 170% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis of snail (Table II).

Activity of acid phosphatase was inhibited to 38%, 67% and 58% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis. Activity of alkaline phosphatase was reduced to 30%, 35% and 32% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis. Protease activity was increased to 136%, 130% and 132% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in the nervous, hepatopancreas and ovotestis of snail *Lymnaea acuminata* (Table II).

Effects on carbohydrate metabolism: Glycogen and pyruvate levels were significantly reduced, while lactate level was significantly enhanced after the exposure to sub-lethal doses in all the body tissues. Lactic dehydrogenase (LDH), cytochrome oxidase and acetylcholinesterase (AChE) activities were significantly reduced, while succinic dehydrogenase (SDH) activity was increased after the exposure.

Glycogen level was reduced to 27%, 40% and 26% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis. Pyruvate level was reduced to 37%, 44% and 39% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis tissue. Lactate level was increased to 175%, 182% and 172% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis (Table IV).

LDH activity was reduced to 26%, 33% and 28% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis tissue. Activity of cytochrome oxidase was reduced to 39%, 43% and 40% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis. AChE activity was reduced to 26%, 22% and 27% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis of snail. SDH

Table I. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (mg/mg) level and activity of protease (µmol of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (µmol substrate hydrolysed/30 min/mg protein) in Nervous (NT), Hepatopancreas (HP) and Ovotestis (OT) tissues of *Lymnaea acuminata* after exposure to 40% and 80% of LC_{50} of aqueous latex extracts of *Croton tiglium* after 24h.

Tabla I. Cambios en los niveles de proteínas totales, aminoácidos libres, ácidos nucléicos (DNA y RNA) (mg/mg) y en la actividad proteasa (µmol de equivalentes de tyrosina/mg de proteína/h) y fosfatasaa ácida y alcalina (µmol sustrato hidrolizado/30 min/mg proteína) en tejido nervioso (NT), hepatopáncreas (HP) y ovotestis (OT) de Lymnaea acuminada *tras exposición a LC_{50} de extracto acuoso de latex de* Croton tiglium *al 40 y al 80% después de 24 horas.*

	Tissues	Control	40% of LC_{50} (24h) (0.024mg,DW/L)	80% of LC_{50} (24h) (0.048mg,DW/L)
Protein	NT	68.0±0.28 (100)	37.8±0.33* (55)	27.8±0.33* (40)
	HP	70.1±0.52 (100)	47.8±0.33* (68)	37.1±0.33* (52)
	OT	72.44±0.80 (100)	39.11±0.70* (54)	27.52±0.84* (38)
Amino acid	NT	34.3±0.36 (100)	49.5±0.22* (129)	48.6±0.36* (141)
	HP	28.8±0.33 (100)	36.6±0.92* (127)	39.1±0.33* (135)
	OT	36.4±0.46 (100)	48.05±0.58* (132)	52.78±0.65* (145)
DNA	NT	72.44±0.80 (100)	57.95±0.80* (80)	50.70±0.70* (70)
	HP	70.11±0.52 (100)	61.68±0.65* (88)	52.58±0.48* (75)
	OT	75.66±0.80 (100)	56.33±0.40* (74)	51.0±0.37* (67)
RNA	NT	62.01±0.28 (100)	52.08±0.35* (84)	40.30±0.40* (65)
	HP	60.10±0.52 (100)	52.89±0.50* (88)	42.07±0.52* (70)
	OT	65.33±0.88 (100)	53.83±0.44* (82)	46.66±0.46* (68)
Protease	NT	0.321±0.056 (100)	0.375±0.057* (117)	0.417±0.048* (130)
	HP	0.342±0.064 (100)	0.393±0.056* (115)	0.427±0.067* (125)
	OT	0.345±0.058 (100)	0.407±0.056* (118)	0.448±0.047* (130)
Acid phosphatase	NT	0.191±0.0004 (100)	0.158±0.0006* (83)	0.120±0.007* (63)
	HP	0.185±0.0006 (100)	0.160±0.0004* (87)	0.129±0.0006* (70)
	OT	0.190±0.0008 (100)	0.161±0.0005* (85)	0.123±0.0004* (65)
Alkaline phosphatase	NT	0.390±0.0004 (100)	0.327±0.0005* (84)	0.261±0.0008* (67)
	HP	0.345±0.0006 (100)	0.303±0.0005* (88)	0.245±0.0006* (71)
	OT	0.385±0.0004 (100)	0.327±0.0008* (85)	0.261±0.0007* (68)

*, Significant ($P<0.05$) Student's 't' test was applied between control and treated groups. Values are mean ±SE of six replicates. Values in parenthesis are percent change with control taken as 100%.

activity was increased to 175%, 168% and 173% of controls after treatment with 80% of LC_{50} (96h) of aqueous latex extracts respectively in nervous, hepatopancreas and ovotestis tissue (Table IV).

Effect on freshwater non-target fish: Higher doses (LC_{90} of snails) have no apparent toxic effect on freshwater fish *Channa punctatus* after 24h exposure. But exposure of fishes to sub-lethal doses (i.e. 40% and 80% of 24h LC_{50} of snail) of aqueous extracts of latex of *Croton tiglium* for 96h caused a significant alteration in nitrogenous and carbohydrates metabolism in different

Table II. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (mg/mg) level and activity of protease (μmol of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (μmol substrate hydrolysed/30 min/mg protein) in Nervous (NT), Hepatopancreas (HP) and Ovotestis (OT) tissues of snail *Lymnaea acuminata* after 96h exposure to 40% and 80% of LC_{50} of aqueous latex extracts of *Croton tiglium* and 7th days after withdrawal.
Tabla II. Cambios en los niveles de proteínas totales, aminoácidos libres, ácidos nucléicos (DNA y RNA) (mg/mg) y en la actividad proteasa (µmol de equivalentes de tyrosina/mg de proteína/h) y fosfatasaa ácida y alcalina (µmol sustrato hidrolizado/30 min/mg proteína) en tejido nervioso (NT), hepatopáncreas (HP) y ovotestis (OT) de Lymnaea acuminada *tras exposición a LC_{50} de extracto acuoso de latex de* Croton tiglium *al 40 y al 80% después de 96 horas y 7 días después de la prueba.*

	Tissues	Control	40% of LC_{50} (96h) (0.006mg,DW/L)	80% of LC_{50} (96h) (0.012mg,DW/L)	7th day after withdrawal
Protein	NT	68.0±0.28 (100)	36.8±0.33* (56)	26.6±0.36* (39)	61.8±0.24= (91)
	HP	70.1±0.52 (100)	38.1±0.33* (55)	31.0±0.49* (45)	67.9±0.02= (97)
	OT	73.33±0.83 (100)	38.1±0.33* (52)	26.9±0.34* (36)	69.6±0.41= (95)
Amino acid	NT	34.3±0.36 (100)	54.3±0.36* (159)	57.6±0.36* (167)	37.0±0.04= (108)
	HP	28.8±0.33 (100)	38.5±0.24* (134)	40.5±0.24* (140)	29.9±0.22= (104)
	OT	37.33±0.83 (100)	60.4±0.25* (162)	63.4±0.25* (170)	40.6±0.34= (109)
DNA	NT	72.66±0.83 (100)	39.96±0.33* (55)	26.15±0.37* (36)	71.93±0.84= (99)
	HP	72.83±1.11 (100)	47.33±0.16* (65)	32.77±0.38* (45)	71.38±1.12= (98)
	OT	75.66±0.80 (100)	37.01±0.40* (49)	21.01±0.40* (28)	68.09±0.71= (90)
RNA	NT	62.66±1.00 (100)	36.34±0.23* (58)	26.31±0.37* (42)	60.78±0.98= (97)
	HP	60.33±0.83 (100)	40.47±0.33* (67)	28.95±0.41* (48)	59.72±0.78= (99)
	OT	65.33±0.88 (100)	32.66±0.54* (50)	22.16±1.11* (34)	60.10±0.81= (92)
Protease	NT	0.344±0.06 (100)	0.409±0.06* (119)	0.382±0.01* (136)	0.330±0.046= (96)
	HP	0.365±0.03 (100)	0.423±0.03* (116)	0.474±0.03* (130)	0.346±0.062= (95)
	OT	0.369±0.01 (100)	0.435±0.01* (118)	0.487±0.01* (132)	0.361±0.028= (98)
Acid phosphatase	NT	0.194±0.009 (100)	0.0911±0.009* (47)	0.0737±0.007* (38)	0.177±0.0007= (91)
	HP	0.190±0.001 (100)	0.096±0.007* (51)	0.127±0.008* (67)	0.174±0.0009= (92)
	OT	0.188±0.002 (100)	0.082±0.002* (44)	0.109±0.001* (58)	0.175±0.0005= (93)
Alkaline phosphatase	NT	0.398±0.002 (100)	0.147±0.003* (37)	0.119±0.001* (30)	0.358±0.0018= (90)
	HP	0.361±0.003 (100)	0.151±0.002* (42)	0.126±0.006* (35)	0.336±0.0012= (93)
	OT	0.392±0.002 (100)	0.152±0.001* (39)	0.125±0.002* (32)	0.372±0.0013= (95)

=, Significant ($P<0.05$) when student's 't' test was applied between 80% of LC_{50} (96h) and withdrawal groups
Details are as given in Table I.

body tissues of fish *Channa punctatus* (Tables V and VI).

Effects on nitrogenous metabolism: Total protein and nucleic acids (DNA and RNA) levels were significantly reduced, while free amino acid level was significantly enhanced after the exposure to sublethal doses in all the studied body tissues. Acid and alkaline phosphatase activities were significantly reduced, while protease activity was increased after the exposure.

Total protein levels were reduced to 78%, 75% and 68% and DNA level was reduced to 72%, 77% and 74% and RNA level was reduced to 67%, 72% and 70%

Table III. Changes in glycogen (mg/g), pyruvate (µmol/g), lactate (mg/g) level and activity of LDH (µmol/mg protein/h), SDH (µmol of dye reduced/min/mg protein), cytochrome oxidase (arbitrary unit/min/mg protein) and AChE (µmol 'SH' hydrolysed/min/mg protein) after 24h exposure to 40% and 80% of LC_{50} of aqueous latex extracts of *Croton tiglium* in Nervous (NT), Hepatopancreas (HP) and Ovotestis (OT) tissues of snail *Lymnaea acuminata.*
Tabla III. Cambios en los niveles de glucógeno (mg/g), piruvato (µmol/g), lactato (mg/g), actividades de LDH (µmol/mg proteína/h), SDH (µmol de colorante reducido/min/mg proteína), citocromo oxidasa (unidad arbitraria/min/mg proteína) y AChE (µmol SH hidrolizado/min/mg proteína) en tejido nervioso (NT), hepatopáncreas (HP) y ovotestis (OT) de Lymnaea acuminada *tras exposición a LC_{50} de extracto acuoso de latex de* Croton tiglium *al 40 y al 80% durante 24 horas.*

	Tissues	Control	40% of LC_{50} (24h) (0.024mg,DW/L)	80% of LC_{50} (24h) (0.048mg,DW/L)
Glycogen	NT	7.9±0.03 (100)	4.2±0.02* (53)	2.8±0.04* (35)
	HP	7.3±0.01 (100)	4.5±0.03* (61)	3.2±0.06* (43)
	OT	8.2±0.05 (100)	4.2±0.02* (52)	2.7±0.03* (34)
Pyruvate	NT	0.698±0.03 (100)	0.391±0.24* (56)	0.276±0.23* (39)
	HP	0.652±0.01 (100)	0.430±0.27* (66)	0.319±0.11* (49)
	OT	0.686±0.04 (100)	0.370±0.18* (54)	0.253±0.27* (37)
Lactate	NT	2.18±0.07 (100)	3.01±0.15* (138)	3.72±0.19* (170)
	HP	2.38±0.05 (100)	3.54±0.06* (149)	4.21±0.02* (177)
	OT	2.14±0.07 (100)	2.19±0.08* (136)	3.57±0.06* (167)
LDH	NT	0.073±0.006 (100)	0.047±0.006* (65)	0.029±0.002* (40)
	HP	0.067±0.001 (100)	0.046±0.003* (69)	0.031±0.002* (47)
	OT	0.072±0.001 (100)	0.048±0.004* (67)	0.027±0.001* (38)
SDH	NT	43.15±0.30 (100)	53.50±0.25* (124)	69.90±0.31* (162)
	HP	40.16±0.26 (100)	51.40±0.29* (128)	62.24±0.27* (155)
	OT	46.11±0.33 (100)	56.25±0.30* (122)	73.31±0.34* (159)
Cytochrome oxidase	NT	16.51±0.12 (100)	10.07±0.16* (61)	8.42±0.18* (51)
	HP	14.59±0.14 (100)	9.48±0.21* (65)	8.46±0.31* (58)
	OT	15.12±0.16 (100)	9.52±0.15* (63)	8.01±0.27* (53)
AChE	NT	0.072±0.0008 (100)	0.048±0.0003* (67)	0.032±0.0003* (45)
	HP	0.092±0.0002 (100)	0.065±0.0007* (71)	0.045±0.0002* (49)
	OT	0.070±0.0002 (100)	0.047±0.0003* (68)	0.032±0.0004* (46)

Details are as given in Table I.

in muscle, liver and gonadal tissue of freshwater fish *Channa punctatus*. Total free amino acid levels were induced to 119%, 125% and 143% of controls after 96h treatment with 80% of LC_{50} of aqueous latex extracts in muscle, liver and gonadal tissues, respectively (Table V).

Activity of acid phosphatase was inhibited to 30%, 37% and 32%. Activity of alkaline phosphatase was reduced to 38%, 40% and 37% and Protease activity was increased to 138%, 128% and 120% of controls after 96h treatment with 80% of LC_{50} (96h) of aqueous latex extracts in muscle, liver and gonadal tissues, respectively (Table V).

Effects on carbohydrate metabolism: Glycogen and pyruvate levels were significantly reduced, while lactate

Table IV. Changes in glycogen (mg/g), pyruvate (μmol/g), lactate (mg/g) level and activity of LDH (μmol/mg protein/h), SDH (μmol of dye reduced/min/mg protein), cytochrome oxidase (arbitrary unit/min/mg protein) and AChE (μmol 'SH' hydrolysed/min/mg protein) after 96h exposure to 40% and 80% of LC_{50} of aqueous latex extracts of *Croton tiglium* in Nervous (NT), Hepatopancreas (HP) and Ovotestis (OT) tissues of snail *Lymnaea acuminata* and 7[th] day after withdrawal.
Tabla IV. Cambios en los niveles de glucógeno (mg/g), piruvato (μmol/g), lactato (mg/g), actividades de LDH (μmol/mg proteína/h), SDH (μmol de colorante reducido/min/mg proteína), citocromo oxidasa (unidad arbitraria/min/mg proteína) y AChE (μmol SH hidrolizado/min/mg proteína) en tejido nervioso (NT), hepatopáncreas (HP) y ovotestis (OT) de Lymnaea acuminada *tras exposición a LC_{50} de extracto acuoso de latex de* Croton tiglium *al 40 y al 80% durante 96 horas y 7 días después de la prueba.*

	Tissues	Control	40% of LC_{50} (96h) (0.006mg,DW/L)	80% of LC_{50} (96h) (0.012mg,DW/L)	7[th] day after withdrawal
Glycogen	NT	7.9±0.03 (100)	3.6±0.17* (46)	2.1±0.06* (27)	7.3±0.03= (93)
	HP	7.3±0.01 (100)	4.1±0.12* (57)	2.9±0.04* (40)	6.8±0.02= (94)
	OT	7.8±0.03 (100)	3.5±0.17* (45)	2.02±0.06* (26)	7.3±0.04= (93)
Pyruvate	NT	0.698±0.03 (100)	0.391±0.02* (56)	0.261±0.04* (37)	0.635±0.27= (91)
	HP	0.657±0.02 (100)	0.407±0.08* (62)	0.289±0.07* (44)	0.592±0.08= (90)
	OT	0.682±0.03 (100)	0.395±0.02* (58)	0.265±0.13* (39)	0.628±0.03= (92)
Lactate	NT	2.18±0.07 (100)	3.08±0.17* (131)	3.92±0.16* (175)	2.46±0.04= (113)
	HP	2.41±0.04 (100)	3.42±0.03* (142)	4.38±0.12* (182)	2.83±0.05= (118)
	OT	2.17±0.07 (100)	2.79±0.08* (129)	3.73±0.03* (172)	2.46±0.03= (113)
LDH	NT	0.073±0.006 (100)	0.032±0.003* (44)	0.019±0.002* (26)	0.065±0.003= (90)
	HP	0.075±0.006 (100)	0.036±0.005* (48)	0.024±0.001* (33)	0.068±0.004= (91)
	OT	0.076±0.003 (100)	0.034±0.003* (46)	0.021±0.001* (28)	0.070±0.003= (90)
SDH	NT	16.41±0.18 (100)	23.63±0.17* (144)	28.7±0.07* (175)	18.38±0.84= (112)
	HP	14.48±0.16 (100)	21.43±0.19* (148)	24.32±0.06* (168)	15.63±0.18= (108)
	OT	18.41±0.07 (100)	26.14±0.08* (112)	31.84±0.17* (173)	20.43±0.20= (111)
Cytochrome oxidase	NT	18.13±0.06 (100)	9.24±0.03* (51)	7.07±0.12* (39)	16.68±0.04= (92)
	HP	14.50±0.15 (100)	7.97±0.12* (55)	6.23±0.03* (43)	13.05±0.12= (90)
	OT	17.23±0.03 (100)	8.95±0.03* (52)	6.89±0.05* (40)	16.18±0.02= (94)
AChE	NT	0.072±0.008 (100)	0.028±0.003* (39)	0.019±0.003* (26)	0.064±0.007= (90)
	HP	0.092±0.006 (100)	0.040±0.012* (44)	0.020±0.013* (22)	0.085±0.002= (93)
	OT	0.071±0.008 (100)	0.028±0.012* (40)	0.019±0.008* (27)	0.063±0.007= (90)

=, Significant (P<0.05) when student's 't' test was applied between 80% of LC_{50} (96h) and withdrawal groups
Details are as given in Table I.

level was significantly enhanced after the exposure to sub-lethal doses in the studied body tissues. Lactic dehydrogenase (LDH), cytochrome oxidase and acetylcholinesterase (AChE) activities were significantly reduced, while succinic dehydrogenase (SDH) activity was increased after the exposure.

Glycogen level was reduced to 70%, 68% and 64%. Pyruvate level was reduced to 33%, 38% and 31% in muscle, liver and gonadal tissue of fish. Lactate

Table V. Changes in total protein, total free amino acids, nucleic acid (DNA and RNA) (mg/mg) level and activity of protease (μmol of tyrosine equivalents/mg protein/h) and acid and alkaline phosphatase (μmol substrate hydrolysed/30 min/mg protein) in different tissues of freshwater fish *Channa punctatus* after exposure to 96h against 40% and 80% of LC_{50} (24h) of aqueous latex extracts of *Croton tiglium* and 7[th] days after withdrawal.
Tabla V. Cambios en los niveles de proteínas totales, aminoácidos libres, ácidos nucléicos (DNA y RNA) (mg/mg) y en la actividad proteasa (μmol de equivalentes de tyrosina/mg de proteína/h) y fosfatasaa ácida y alcalina (μmol sustrato hidrolizado/30 min/mg proteína) en distintos tejidos del pez Channa punctatus *tras exposición a LC_{50} (24h) de extracto acuoso de latex de* Croton tiglium *al 40 y al 80% después de 96 horas y 7 días después de la prueba.*

	Tissues	Control	40% of LC_{50} (24h) (0.024 mg,DW/L)	80% of LC_{50} (24h) (0.048 mg,DW/L)	7th day after withdrawal
Protein	Muscle	160.1±0.77 (100)	133.5±0.24* (83)	124.6±0.26* (78)	156.8±0.71= (98)
	Liver	141.0±0.69 (100)	119.8±0.24* (85)	105.7±0.24* (75)	136.7±1.00= (97)
	Gonadal	136.6±1.00 (100)	117.4±0.12* (86)	92.8±0.08* (68)	131.1±0.45= (96)
Amino acid	Muscle	28.5±0.24 (100)	30.4±0.29 (107)	33.9±0.40* (119)	29.3±0.23= (103)
	Liver	22.6±0.40 (100)	24.8±0.47 (110)	28.2±0.40* (125)	23.7±0.38= (105)
	Gonadal	20.6±0.78 (100)	28.2±0.02* (137)	29.4±0.02* (143)	21.4±0.10= (104)
DNA	Muscle	142.44±0.75 (100)	123.9±0.16* (87)	102.7±0.14* (72)	136.7±0.69= (96)
	Liver	140.01±0.71 (100)	133.0±0.07 (95)	107.8±0.14* (77)	134.4±0.51= (96)
	Gonadal	145.00±0.75 (100)	117.40±0.45* (81)	107.30±0.26* (74)	137.7±0.34= (95)
RNA	Muscle	103.00±0.28 (100)	84.41±0.03* (82)	69.01±0.04* (67)	99.9±0.28= (97)
	Liver	100.0±0.29 (100)	86.02±0.18* (86)	72.01±0.18* (72)	100.0±0.21= (96)
	Gonadal	106.60±0.61 (100)	85.20±0.43* (80)	74.60±0.28* (70)	98.5±0.17= (93)
Protease	Muscle	0.592±0.011 (100)	0.752±0.147* (127)	0.817±0.018* (138)	0.639±0.061= (108)
	Liver	0.608±0.016 (100)	0.681±0.018* (112)	0.778±0.015* (128)	0.571±0.012= (94)
	Gonadal	0.698±0.017 (100)	0.803±0.015* (115)	0.838±0.016* (120)	0.739±0.154= (106)
Acid phosphatase	Muscle	0.283±0.013 (100)	0.113±0.011* (40)	0.84±0.013* (30)	0.260±0.0123= (92)
	Liver	0.297±0.017 (100)	0.130±0.011* (44)	0.109±0.009* (37)	0.276±0.013= (93)
	Gonadal	0.288±0.015 (100)	0.120±0.007* (42)	0.092±0.017* (32)	0.267±0.012= (93)
Alkaline phosphatase	Muscle	0.434±0.012 (100)	0.177±0.007* (41)	0.164±0.04* (38)	0.394±0.002= (91)
	Liver	0.463±0.005 (100)	0.199±0.008* (43)	0.185±0.007* (40)	0.426±0.003= (92)
	Gonadal	0.438±0.012 (100)	0.175±0.007* (40)	0.162±0.004* (37)	0.403±0.004= (92)

=, Significant ($P<0.05$) when student's 't' test was applied between 80% of LC_{50} (24h) and withdrawal groups
Details are as given in Table I.

level was increased to 165%, 172% and 162% of controls after 96h treatment with 80% of LC_{50} (96h) of aqueous latex extracts in muscle, liver and gonadal tissues of fish, respectively (Table VI).

LDH activity was reduced to 86%, 83% and 84% and activity of cytochrome oxidase was reduced to 75%, 73% and 76%. AChE activity was reduced to 32%, 36% and 32% in muscle, liver and gonadal tissue of fish, respectively. SDH activity was increased to 124%, 126% and 122% of controls after 96h treatment with 80% of LC_{50} of aqueous latex extracts in muscle, liver and gonadal tissues of fish, respectively (Table VI).

Table VI. Changes in glycogen (mg/g), pyruvate (µmol/g), lactate (mg/g) level and activity of LDH (µmol/mg protein/h), SDH (µmol of dye reduced/min/mg protein), cytochrome oxidase (arbitrary unit/min/mg protein) and AChE (µmol 'SH' hydrolysed/min/mg protein) in different tissues of *Channa punctatus* after exposure to 96h against 40% and 80% of LC_{50} (24h) of aqueous latex extracts of *Croton tiglium* and 7[th] days after withdrawal.
Tabla IV. Cambios en los niveles de glucógeno (mg/g), piruvato (µmol/g), lactato (mg/g), actividades de LDH (µmol/mg proteína/h), SDH (µmol de colorante reducido/min/mg proteína), citocromo oxidasa (unidad arbitraria/min/mg proteína) y AChE (µmol SH hidrolizado/min/mg proteína) en distintos tejidos del pez Channa punctatus *tras exposición a LC_{50} (24h) de extracto acuoso de latex de* Croton tiglium *al 40 y al 80% después de 96 horas y 7 días después de la prueba.*

	Tissues	Control	40% of LC_{50} (24h) (0.024 mg,DW/L)	80% of LC_{50} (24h) (0.048 mg,DW/L)	7[th] days after withdrawal
Glycogen	Muscle	1.92±0.001 (100)	1.46±0.006* (76)	1.34±0.04* (70)	1.67±0.01$^{=}$ (87)
	Liver	1.98±0.002 (100)	1.44±0.003* (73)	1.34±0.04* (68)	1.69±0.03$^{=}$ (85)
	Gonadal	1.73±0.01 (100)	1.28±0.03* (74)	1.10±0.02* (64)	1.51±0.03$^{=}$ (87)
Pyruvate	Muscle	2.416±0.018 (100)	1.232±0.016* (51)	0.797±0.028* (33)	2.150±0.017$^{=}$ (89)
	Liver	3.076±0.018 (100)	1.876±0.036* (61)	1.168±0.008* (38)	2.768±0.035$^{=}$ (90)
	Gonadal	2.133±0.036 (100)	1.045±0.017* (49)	0.661±0.023* (31)	1.95±0.016$^{=}$ (91)
Lactate	Muscle	2.816±0.018 (100)	3.379±0.092* (120)	4.646±0.064* (165)	3.041±0.082$^{=}$ (108)
	Liver	2.233±0.023 (100)	2.925±0.023* (131)	3.840±0.076* (172)	2.500±0.069$^{=}$ (112)
	Gonadal	3.816±0.083 (100)	4.502±0.088* (118)	6.181±0.092* (162)	4.159±0.043$^{=}$ (109)
LDH	Muscle	431.5±0.88 (100)	392.6±0.84 (91)	371.0±0.85* (86)	392.7±0.83$^{=}$ (91)
	Liver	517.0±1.0 (100)	475.6±0.81 (92)	429.1±0.88* (83)	465.3±0.78$^{=}$ (90)
	Gonadal	434.2±0.87 (100)	403.8±0.72 (93)	364.2±0.85* (84)	395.1±0.81$^{=}$ (91)
SDH	Muscle	49.4±0.21 (100)	56.3±0.21* (114)	61.2±0.27* (124)	53.8±0.21$^{=}$ (109)
	Liver	52.6±0.23 (100)	58.9±0.22* (112)	66.2±0.22* (126)	58.3±0.23$^{=}$ (111)
	Gonadal	54.4±0.26 (100)	63.1±0.18* (116)	66.3±0.15* (122)	59.2±0.26$^{=}$ (107)
Cytochrome oxidase	Muscle	25.92±0.21 (100)	22.03±0.23* (85)	19.44±0.22* (75)	24.36±0.33$^{=}$ (94)
	Liver	28.30±0.07 (100)	23.77±0.21* (84)	20.65±0.22* (73)	20.65±0.022$^{=}$ (91)
	Gonadal	31.20±0.07 (100)	27.14±0.13* (87)	23.71±0.16* (76)	25.75±0.19$^{=}$ (92)
AChE	Muscle	0.093±0.0012 (100)	0.049±0.0006* (53)	0.029±0.0007* (32)	0.083±0.0002$^{=}$ (90)
	Liver	0.099±0.0011 (100)	0.054±0.0004* (55)	0.035±0.0003* (36)	0.092±0.0001$^{=}$ (92)
	Gonadal	0.095±0.0025 (100)	0.049±0.0008* (52)	0.030±0.0006* (32)	0.087±0.0005$^{=}$ (91)

$^{=}$, Significant ($P<0.05$) when student's 't' test was applied between 80% of LC_{50} (24h) and withdrawal groups
Details are as given in Table I.

DISCUSSION

It is evident from the results presented here that the aqueous extracts of the latex of *Croton tiglium* besides being potent molluscicides (YADAV AND SINGH, 2001) are toxic to fish *Channa punctatus* at higher concentrations and longer exposure periods. The exposure to 40% and 80% of snail LC_{50} for 24h did not caused any significant changes in the level of carbohydrate and nitrogenous metabolism of fish tissues, while this treatment continued up to 96 hours decreased the carbohydrate and nitrogenous metabolism levels significantly.

MOMMENSEN AND WALSH (1992) reported that proteins are mainly involved in the architecture of the cell, which is the chief source of nitrogenous metabolism and during chronic period of stress they are also a source of energy. During stress condition, snails needed more energy to detoxify the toxicants and to overcome stress (ARUNACHALAM, JAYALAKSHAMI AND ABOOKER, 1980). The depletion of protein fraction in nervous, hepatopancreas and ovotestis tissues may have been due to their degradation and possible utilization of degraded products for metabolic purposes. Increment in free amino acids level was the result of breakdown of protein for energy requirement and impaired incorporation of amino acids in protein synthesis, but it also could be attributed to the lesser use of amino acids and their involvement in the maintenance of an acid-base balance. Stress conditions induce the transamination pathway. Inhibition of DNA synthesis might affect both protein as well as amino acid levels by decreasing the level of RNA in protein synthesis machinery (NORDENSKJOLD, SODERHALL AND MOLDEUS, 1979). Euphorbiales are a potential inhibitor of DNA synthesis, which might result in reduction of RNA level and consequently affecting protein synthesis and amino acid levels as showed are results.

The enzyme protease functions in hydrolysing proteins to free amino acids and small peptides. The increase in the protease activity corroborates with the enhancement in the FAA (Free amino acids) level of the three tissues, the formation of which might be the result of protein hydrolysis of the three tissues suggesting stimulation during toxic stress. Similar trend of results on protease activity was also reported by several workers in different animals (*Tilapia mossambica* (Peters), *Pila globosa* (Swaimson) including mammal (MILLWARD, 1970; SIVA PRASADA RAO, 1980; SIVAIAH, 1980; KABEER, SAHIB, SIVA PRASAD, SAMBASIVA AND RAMANA RAO, 1984). SINGH AND AGARWAL (1992) reported that the latices of several euphorbious plants significantly reduced the alkaline and acid phosphatase activity in nervous tissue of *Lymnaea acuminata.* So the reduction in protein level may be due to the inhibition of alkaline phosphatase activity, as it plays an important role in protein synthesis (PILO, ASNANI AND SHAH, 1972) and other secretary activities (IBRAHIM, HIGAZI AND DEMIAN, 1974).

Carbohydrates are the primary and immediate source of energy of the metabolism. ARASTA, BAIS AND THAKUR, (1996) suggested that in stress condition, carbohydrates reserves depleted to meet energy demand, thus depletion of glycogen may be due to direct utilization for energy generation, a demand caused by active moiety-induced hypoxia. Euphorbiales inhibit acetylcholinesterase activity, which results in an increase of acetylcholine contents (SINGH AND AGARWAL, 1984; SINGH AND AGARWAL, 1990, 1991; SINGH *ET AL.*, 1996). Increase level of acetylcholine has been shown to enhance the secretion of catecholamine (NILSSON, ABRAHAMSSON AND GROVE, 1976), which may bring about glycogenolysis. Thus, glycogenolysis seems to be the result of increased secretion of catecholamine due to stress (SINGH AND SRIVASTAVA, 1992; SINGH AND AGARWAL, 1993). Decrease in pyruvate level is due to higher energy demand during exposure, which is suggests the possibility of a shift towards anaerobic dependence due to a remarkable drop in aerobic segment. The decrease in pyruvate could be due to its conversion to lactate, or due to its mobilization to form amino acids, lipids, triglycerides and glycogen synthesis in addition to its role as a detoxification factor (SATHYA PRASAD, 1983). The increase in lactate also suggests a shift towards anaerobiosis as a consequence of hypoxia leading to respiratory distress (DOMSCHE, DOMSCHE AND CLASSEN, 1971; SIVA PRASADA RAO, 1980). Development of such internal hypoxic conditions may be ultimately responsible for the shift to the less efficient anaerobic metabolism, evidenced by the change in lactate content observed during this study.

Lactic dehydrogenase (LDH) forms the centre for a delicately balanced equilibrium between catabolism and anabolism of carbohydrates (Everse and Kalpan, 1973). Lactic dehydrogenase (LDH) catalyze the inter-conversions of lactic acid and pyruvic acid during anaerobic conditions. Inhibition of LDH and cytochrome oxidase activity indicates that latex extracts of *Croton tiglium* significantly inhibits aerobic, as well as anaerobic metabolism in exposed animals. Succinic dehydrogenase (SDH) is one of the active regulatory enzymes of the TCA cycle. The reasons for an increase SDH level after exposure to extracts of latex are not clear. A similar situation was observed by GUPTA and KAPOOR (1975), who reported a increase of SDH level in malathion exposed, irradiated rats.

Cytochrome oxidase is a terminal enzyme of the electron transport chain. Inhibition in cytochrome oxidase activity by plant moieties supports that Euphorbiales show a profound impact on the oxidative metabolism, possibly due to their influence on respiratory process like electron transport system (ETS). Decrease in cytochrome oxidase might be either the result of reduced availability of O_2, which in turns has reduce the capacity of electron transport system to produce ATP molecules or should be due to the direct impact of the active moiety. Anticholinesterase compounds are known to usually inhibit mitochondrial reactions like the function of the cytochrome oxidase in electron transport system. Since Euphorbiales are anticholinesterase inhibitor, they disrupt Kreb's cycle by diminishing the rate of electron transport system and oxidative phosphorylation, resulting in less synthesis of ATP.

Withdrawal experiments were performed to see whether biochemical alteration by exposure to plant moiety would return normal, if the treatment were discontinued. There was nearly complete recovery of total protein, total free amino acid, lactate, nucleic acid (DNA and RNA), pyruvate level and in the activity of cytochrome oxidase, SDH, protease, , LDH, AChE and acid and alkaline phosphatase and a partial recovery of glycogen level in the different body tissues of snail and fish (Table II, IV, V and VI) .

We therefore believe that these plant extracts may eventually be of great value for the control of aquatic non-target organisms.

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New data on the benthic Opisthobranch Molluscs from the Archipelago of Fernando de Noronha (Brazil), with description of a new species of *Aegires* Lovén, 1844

Nuevos datos sobre los moluscos opistobranquios bentónicos del Archipiélago de Fernando de Noronha, con descripción de una nueva especie de *Aegires* Lovén, 1844

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ABSTRACT

New data on the opisthobranch fauna from the Archipelago Fernando de Noronha are presented in this paper, 111 specimens distributed among 12 species were studied and 11 of them are a new record for the archipelago. A new species of genus *Aegires* is described. The external anatomy and radula of this specimen are compared with other species of the genus.

RESUMEN

En este trabajo se presentan nuevos datos sobre la fauna de moluscos opistobranquios del Archipiélago Fernando de Noronha, se estudian un total de 111 ejemplares repartidas en 12 especies, siendo que 11 de ellas son nuevas citas para el archipiélago. Se describe una nueva especie de Nudibranchia perteneciente al género *Aegires* Lovén, 1844. Se compara la anatomía externa y rádula de este especimen con otras especies del género.

KEY WORDS: Mollusca, Opisthobranchia, Fernando de Noronha, Aegires, new species.
PALABRAS CLAVE: Mollusca, Opisthobranchia, Fernando de Noronha, Aegires, nueva especie.

INTRODUCTION

The Archipelago Fernando de Noronha (Brazil) lies off Cape São Roque, State of Rio Grande do Norte, about 195 nautical miles offshore (03° 51′ S, 32° 25′ W). Besides the island of Fernando de Noronha, several smaller islands, all of volcanic origin, compose the Archipelago of the same name. The archipelago lies in the north branch of the South equatorial oceanic current, with high temperature, salinity and transparency. The intertidal bottoms are mostly of hard substrate with a few sandy beaches, having a dominant community of seaweeds (calcareous algae, *Sargassum* sp. and filamentous green algae) and Vermetidae.

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Table I. Opisthobranchs from Fernando de Noronha Archipelago recorded by MATTHEWS AND KEMPF (1970); RIOS AND BARCELLOS (1979) and present paper. 000: abundant (20 or more specimens); 00: moderate (20>n>2); 0: rare (n≤ 2).
Tabla I. Opistobranquios del Archipielado de Fernando de Noronha citados por MATTHEWS AND KEMPF (1970); RIOS AND BARCELLOS (1979) y en el presente trabajo. 000: abundante (20 o más ejemplares); 00: moderado (20>n>2); 0: raro (n≤ 2).

Species	Matthews and Kempf (1970)	Rios and Barcellos (1979)	Present paper
Cephalaspidea			
Micromelo undata	X		00
Hydatina vesicaria	X		
Atys sp.	X		
Atys mandrewii		X	
Retusa canaliculata	X		
Cylichna noronhensis	X		
Anaspidea			
Aplysia sp.	X		
Stylocheilus longicauda			000
Ascoglossa			
Caliphylla mediterranea			00
Elysia ornata			000
Elysia flava			0
Notaspidea			
Pleurobranchus areolatus			0
Berthelinia caribbea		X	
Berthella stellata			0
Doridacea			
Doris sp.	X		
Aegires absalaoi			0
Chromodoris neona			00
Platydoris angustipes			0
Dendrodoris senegalensis			00
Aeolidacea			
Phidiana sp.			00

MATTHEWS AND KEMPF (1970) provided a checklist of the molluscan fauna from the Archipelago of Fernando de Noronha and Atol das Rocas. Although more than 160 species of Molluscs were listed, however only seven species of opisthobranch gastropods were cited. Besides four species were referred by LOPES AND ALVARENGA (1957) this material was not found by these authors, and finally two species was referred by RIOS AND BARCELLOS (1979) (Table I).

In this paper new species of opisthobranchs found in the Archipelago of Fernando de Noronha are cited, based on material obtained by the authors during two visits in 1999 and 2000.

MATERIAL AND METHODS

The species studied in this paper were collected by diving down to 20 m along the littoral, during two trips to

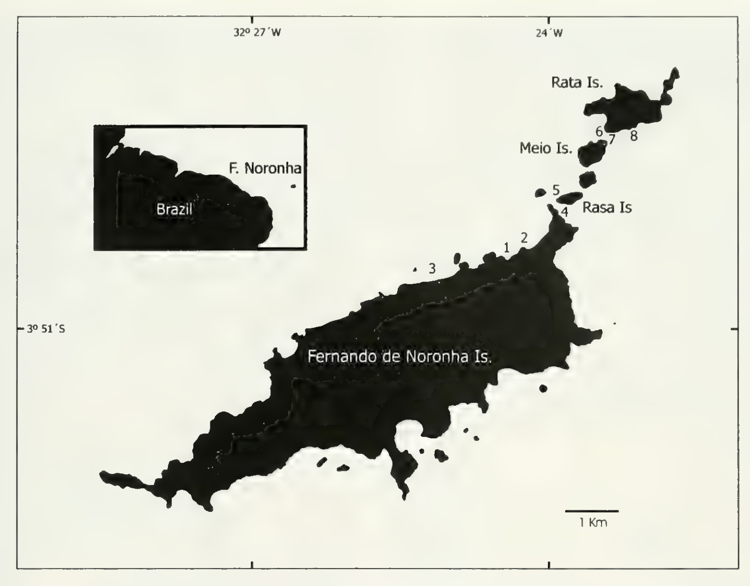


Figure 1. Sampling localities. 1 Praia do Cachorro, 2 Porto, 3 Praia da Conceição, 4 Air France Is. Rasa, 5 Rasa Is., 6 Buraco do Inferno Rata Is., 7 Lage Dois Irmãos between Rata and Meio Is., 8 Ressurretta Rata Is.

Figura 1. Localidades de muestreo. 1 Praia do Cachorro, 2 Porto, 3 Praia da Conceição, 4 Air France Is. Rasa, 5 Rasa Is., 6 Buraco do Inferno Rata Is., 7 Lage Dois Irmãos entre Rata y Meio Is., 8 Ressurretta Rata Is.

Archipelago de Fernando de Noronha in 1999 and 2000. The sampling stations are represented in Figure 1. For each species the dates and depth of collection, stations, and lengths of the specimens alive are recorded. Besides this, the distributions in Brazil and in other geographical areas are included.

The specimens collected have been deposited in the collections of the Department of Physiology and Zoology of the University of Seville and Department of Ecology and Animal Biology of the University of Vigo (Spain) and the holotype of *Aegires* was deposited in the Museu Oceanográfico "Prof. Eliézer de Carvalho Rios" from the Foundation University of Rio Grande, in Rio Grande, Brazil, with code number 42.011.

RESULTS

Class GASTROPODA Cuvier, 1797
Subclass OPISTHOBRANCHIA Milne-Edwards, 1848
Order CEPHALASPIDEA Fischer, P. 1883
Family Hydatinidae Pilsbry, 1895
Genus *Micromelo* Pilsbry, 1895

Micromelo undata (Bruguière, 1792) (Fig. 2A)

Material collected: 06/07/1999; station: Praia do Cachorro (Fernando de Noronha Is.); depth: intertidal; 1 specimen; length: 17 mm. 08/07/1999; station: Praia do Cachorro (Fernando de Noronha

Is.); depth: intertidal; 1 specimen; length: 30 mm. 07/07/1999; station: Porto (Fernando de Noronha Is.); depth: 1 m; 5 specimens; length in mm: 15.5 to 22 mm. 15/06/2000; station: Porto (Fernando de Noronha Is.); depth: 1 m; 1 specimen; length: 15 mm. 19/06/2000; station: Porto (Fernando de Noronha Is.); depth: 1 m; 1 specimen; length: 17 mm.

Habitat: On rocks with algae and in tidal pools with *Cystoseira*.

Brazilian distribution: NE Brazil, from Pernambuco to Bahia (MARCUS AND MARCUS, 1967; RIOS, 1994). Fernando de Noronha Is. (MARCUS AND MARCUS, 1967; MATTHEWS AND KEMPF, 1970; RIOS, 1994).

Other geographical areas distribution: Circumtropical species, Caribbean Sea, Atlantic Ocean, Macaronesia, Ascension Is, Southern Africa and Indo-Pacific Ocean (GOSLINER, 1987; MALAQUIAS, 2001; MARCUS AND MARCUS, 1967; MARCUS, 1977; MIKKELSEN, 1995; ORTEA, MORO, BACALLADO AND HERRERA, 2000; RIOS, 1994).

Order ANASPIDEA Fischer P., 1883
Family DOLABRIFERIDAE Pilsbry, 1895
Genus *Stylocheilus* Gould, 1852

Stylocheilus longicauda (Quoy and Gaimard, 1824) (Fig. 2B)

Material collected: 07/07/1999; station: Porto (Fernando de Noronha Is.); depth: intertidal; 1 specimen; length: 22 mm. 08/07/1999; station: Praia da Conceição (Fernando de Noronha Is.); depth: intertidal; 7 specimens; length: 15 to 33 mm. 10/07/1999; station: Air France (Rasa Is.); depth: intertidal; 3 specimens; length: 18 to 20 mm. 16/06/2000; station: Rasa Is.; depth: intertidal; 17 specimens; length: 12 to 36 mm. 17/06/2000; station: Buraco do Inferno (Rata Is.); depth: 12 m; 4 specimens; length: 19 to 29 mm. 19/06/2000; station: Buraco do Inferno (Rata Is.); depth: 14 m; 6 specimens; length: 6 to 28.

Habitat: On and under rocks, associated with masses of red algae.

Brazilian distribution: Pernambuco, Recife (MARCUS AND MARCUS, 1970).

Other geographical areas distribution: Circumtropical (FARMER, 1967; MARCUS, 1977; MARSHALL AND WILLAN, 1999; RIOS, 1994).

Order SACOGLOSSA Von Ihering, 1876
Family HERMAEIDAE Adams H. and A.
Genus *Caliphylla* Costa, A. 1869

Caliphylla mediterranea A. Costa, 1867 (Figs. 2C, D)

Material collected: 15/06/2000; station: Porto (Fernando de Noronha Is.); depth: 5 m; 1 specimen; length: 16 mm. 19/06/2000; station: Porto (Fernando de Noronha Is.); depth: 5 m; 10 specimens; length: 8 to 19 mm.

Habitat: Associated with filamentous green algae.

Brazilian distribution: South Brazil in São Paulo State (Santos, São Sebastião Is., Cananeia) (MARCUS, 1977; RIOS, 1994).

Other geographical areas distribution: Mediterranean Sea; Atlantic Ocean from Spain to Senegal, Canary Is. and Caribbean Sea (CERVERA, TEMPLADO, GARCÍA-GÓMEZ, BALLESTEROS, ORTEA, GARCÍA, ROS AND LUQUE, 1988; GASCOIGNE, 1979; JENSEN AND CLARK, 1983; MARCUS AND MARCUS, 1970; MARCUS, 1977; ORTEA *ET AL.*, 2000; PRUVOT-FOL, 1954; SCHMEKEL AND PORTMANN, 1982).



Figure 2. A: *Micromelo undata*; B: *Stylocheilus longicauda*; C, D: *Caliphylla mediterranea*; E, F: *Elysia ornata*; G: *Elysia flava*; H: *Pleurobranchus areolatus*; I: *Aegires absalaoi* n. sp.; J: *Chromodoris neona*; K: *Platydoris angustipes*; L: *Dendrodoris senegalensis*; M: *Phidiana* sp.

Figura 2. A: Micromelo undata*; B:* Stylocheilus longicauda*; C, D:* Caliphylla mediterranea*; E, F:* Elysia ornata*; G:* Elysia flava*; H:* Pleurobranchus areolatus*; I:* Aegires absalaoi *n. sp.; J:* Chromodoris neona*; K:* Platydoris angustipes*; L:* Dendrodoris senegalensis*; M:* Phidiana *sp.*

Family ELYSIIDAE Forbes and Hanley, 1851
Genus *Elysia* Risso, 1818

Elysia ornata (Swainson, 1840) (Figs. 2E, F)

Material collected: 08/07/1999; station: Lage dois Irmãos, between Meio Is. and Rata Is. (Fernando de Noronha Is.); depth: 18 m; 1 specimen; length: 22 mm. 15/06/2000; station: Porto (Fernando de Noronha Is.); depth: 5 m; 22 specimens; length: 22 to 36 mm. 17/06/2000; station: Buraco do Inferno (Rata Is.); depth: 12 m; 1 specimen; length: 12.5 mm. 19/06/2000; station: Porto (Fernando de Noronha Is.); depth: 5 m; 12 specimens; length: 15 to 36 mm.

Habitat: Associated with filamentous green algae.

Brazilian distribution: Present paper, first record to Brazilian coast.

Other geographical areas distribution: Circumtropical, Atlantic Ocean from Caribbean Sea to Canary Is. and Azores Archipelago; Indo-Pacific Ocean in Hawaii, Vietnam and Australia (MALAQUIAS, 2001; MARCUS AND MARCUS, 1970; MARCUS, 1980; MARSHALL AND WILLAN, 1999; ORTEA *ET AL.*, 2000; THOMPSON, 1977).

Elysia flava Verrill, 1901 (Fig. 2G)

Material collected: 08/07/1999; station: Praia da Conceição (Fernando de Noronha Is.); depth: intertidal; 1 specimen; length: 6 mm.

Habitat: Associated with filamentous green algae.

Brazilian distribution: Present paper, first record to Brazilian coast.

Other geographical areas distribution: From Mediterranean Sea, Canary Is. and Madeira Archipelago to Caribbean Sea (CLARK, 1984; MALAQUIAS, CERVERA, ABREU AND LÓPEZ-GONZÁLEZ, 2001; MARCUS, 1980; ORTEA, 1981; ORTEA *ET AL.*, 2000; THOMPSON, 1977, 1983; THOMPSON AND JAKLIN, 1988)

Order NOTASPIDEA Fischer P. 1883
Family PLEUROBRANCHIDAE Férussac, 1822
Genus *Pleurobranchus* Cuvier, 1804

Pleurobranchus areolatus Mörch, 1863 (Fig. 2H)

Material collected: 19/06/2000; station: Buraco do Inferno (Rata Is.); depth: 14 m; 1 specimen; length: 15 mm.

Habitat: Under rocks with ascidians, sponges, and other invertebrates.

Brazilian distribution: Cabo Frio (Rio de Janeiro State) (MARCUS, 1977; RIOS, 1994).

Other geographical areas distribution: East Pacific in Gulf of California, Panama and Galapagos Islands. Atlantic Ocean from Florida to Canary Islands and Ghana (BERTSCH AND SMITH, 1973; EDMUNDS 1968; MARCUS AND MARCUS, 1967; ORTEA *ET AL.*, 2000; RIOS, 1994).

Genus *Berthella* de Blainville, 1824

Berthella stellata (Risso, 1826)

Material collected: 10/07/1999; station: Air France (Rasa Is.); depth: intertidal; 1 specimen; length: 7 mm.

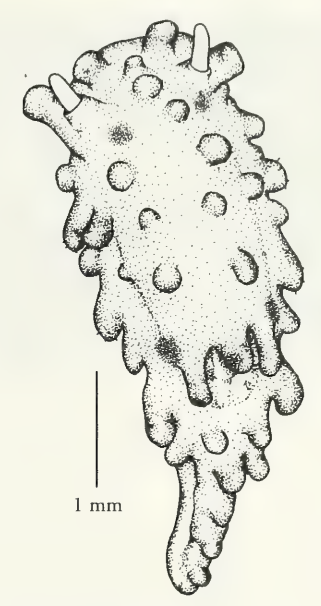


Figure 3. *Aegires absalaoi* n. sp., external morphology.
Figura 3. Aegires absalaoi n. sp., m*orfología externa.*

Habitat: On rocks with ascidians, sponges and briozoans.

Brazilian distribution: Cabo Frio (Rio de Janeiro State), Ubatuba, Ilhabela (São Paulo State) (RIOS, 1994, cited as *B. tupala*; MARCUS, 1957).

Other geographical areas distribution: *B. stellata* is a circumtropical species, found from the Mediterranean Sea and the Canary Islands to the Atlantic coast of Panama. On the Pacific coast, Gulf of California, Bahia Tortugas, Baja California (CERVERA *ET AL.*, 1988; GOSLINER AND BERTSCH, 1988; ORTEA *ET AL.*, 2000; PRUVOT-FOL, 1954).

Order NUDIBRANCHIA de Blainville, 1814
Suborder DORIDINA Odhner, 1934
Family AEGIRETIDAE Fischer P., 1883
Genus *Aegires* Lovén, 1844

Aegires absalaoi n. sp. (Fig. 2I, 3, 4)

Material collected: 19/06/2000; station: Buraco do Inferno (Rata Is.); depth: 14 m; 1 specimen; length: 5 mm. The holotype was deposited in the Museu Oceanográfico "Prof. Eliézer de Carvalho Rios" from the Foundation University of Rio Grande, in Rio Grande, Brazil, with code number 42.011

Etymology: The species has been named *Aegires absalaoi* in honour of Dr. Ricardo Silva Absalão, Brazilian malacologist and friend.

Habitat: Under stones with sponges, and calcareous detritus.

Description: The unique specimen has a firm limaciform body, with abundant spicules in the tegument. Dorsum with blunt tubercles, arranged in two marginal and one medial longitudinal rows in front of the gills, and one row

on the tail. There are two tubercles in front the rhinophores and other two mid-lateral tubercles between the marginal and central rows. There are three gills protected by three large anterior tubercles. The rhinophores are smooth and the rhinophoral sheaths have only a prominent lobe on the external side (Figure 3).

The colour pattern alive is creamy white with some brown spots on the dorsum. At the apex of some tubercles there is a minute brown spot (Figure 2I).

The labial armature lacks differentiated elements (Figure 4A). The radula has a formula of 15 x 10-0-10. The teeth are hook-shaped being the inner teeth slightly smaller than the outer (Figure 4B).

Discussion: Five species of the genus *Aegires* are known in Atlantic Ocean, *A. punctilucens* (Orbigny, 1837), *A. sublaevis* Odhner, 1932, *A. ortizi* Templado, Luque and Ortea, 1987, *A. gomezi* Ortea, Luque and Templado 1990 and *A. palensis* Ortea, Luque and Templado 1990. Externally, our specimen differs from these species by the presence of the rhinophoral sheath with five lobes and iridiscent blue spots scattered over the back of *A. punctilucens*; the body of lemon-yellow colour, and presence of two longitudinal crest on the dorsum that join at the level of the rhinophores of *A. sublaevis* (Templado, Luque and Ortea, 1987); the presence of rhinophoral sheaths having three large tubercles on the side distal to the rhinophores and a dark brown spot on the top of each tubercle of *A. ortizi* (Templado *et al.*, 1987), the presence of prominent oblique ridges of *A. gomezi* (Ortea, Luque and Templado, 1990), and the color pattern, the presence of four series of two tubercles each joined by heavy ridges and rhinophoral sheath with six lobes of *A. palensis* (Ortea *et al.*, 1990).

Internally, our specimen differs of the rest of species by the presence of radular teeth with a denticle in their inner middle part in the radula of *A. ortizi* (Templado *et al.*, 1987); labial armature with rods in *A. punctilucens* and *A. gomezi* (Ortea *et al.*, 1990).

Finally, our species is externally quite similar to *A. albopunctatus* MacFarland 1905, from the Pacific Ocean, by the colour pattern, white with irregularly scattered small dark-brown spots and external anatomy, having the dorsum with short blunt tubercles, cylindrical or with slightly expanded apices and tubercles, and tegument with numerous spicules. However, both species differ by the presence of rhinophoral sheaths with five or six high, rounded tubercles in the Pacific species (MacFarland, 1966) and only one in *A. absalaoi*.

Family Chromodorididae Bergh, 1891
Genus *Chromodoris* Alder and Hancock, 1855

Chromodoris neona (Marcus, 1955) (Fig. 2J)

Material collected: 07/07/1999; station: Buraco do Inferno (Rata Is.); depth: 10 m; 2 specimens; length: 19, 21 mm. 09/07/1999; station: Buraco do Inferno (Rata Is.); depth: 7 m; 1 specimen; length: 23 mm.

Habitat: On big rocks with sponges, ascidians, hydrozoans, briozoans and other invertebrates.

Brazilian distribution: São Paulo (Marcus, 1955); Cabo Frio (Marcus and Marcus, 1967); Cabo Frio (Rio de Janeiro State), Ubatuba, São Sebastião (São Paulo State) (Rios, 1994).

Other geographical areas distribution: Caribbean Sea in Florida, east of Panama, Colombia (Marcus and Marcus, 1967; Marcus, 1977; Rios, 1994).

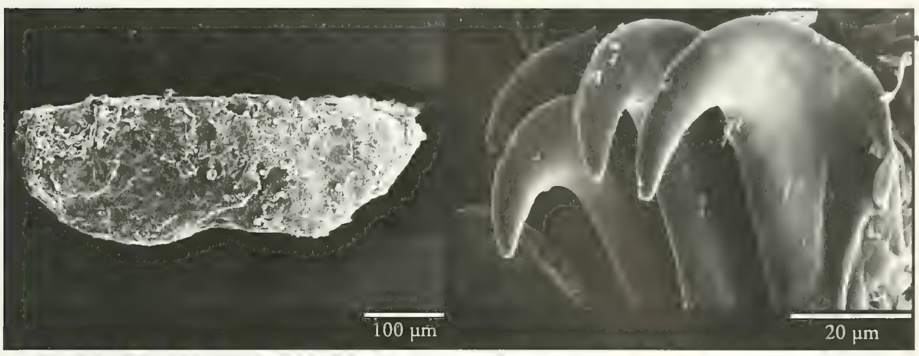


Figure 4. *Aegires absalaoi* n. sp. A: Scanning electron micrographs of jaw; B: detail of the radular teeth.
Figura 4. Aegires absalaoi *n. sp. A: Fotos al microscopio electrónico de la mandíbula; B: detalle de los dientes radulares.*

Family PLATYDORIDIDAE Bergh, 1891
Genus *Platydoris* Bergh, 1877

Platydoris angustipes (Mörch, 1863) (Fig. 2K)

Material collected: 07/07/1999; station: Porto (Fernando de Noronha Is.); depth: 1 m; 1 specimen; length: 72 mm. 17/06/2000; station: Buraco do Inferno (Rata Is.); depth: 12 m; 1 specimen; length: 20 mm.

Habitat: Under stones associated with sponges and ascidians.

Brazilian distribution: Maranhão, Recife, PE, off Alagoas and Bahia (RIOS, 1994)

Other geographical areas distribution: Caribbean Sea in Florida, Dry Tortugas, Jamaica, Virgin Islands (MARCUS AND MARCUS, 1967).

Family DENDRODORIDIDAE O'Donoghue, 1924
Genus *Dendrodoris* Ehrenberg, 1831

Dendrodoris senegalensis Bouchet, 1975 (Fig. 2L)

Material collected: 07/07/1999; station: Porto (Fernando de Noronha Is); depth: intertidal; 1 specimen; length: 21 mm. 19/06/2000; station: Buraco do Inferno (Rata Is.); depth: 14 m; 2 specimens; length: 9, 20 mm.

Habitat: Under stones associated with sponges and ascidians.

Brazilian distribution: Present paper.

Other geographical areas distribution: Only known from Cabo Verde Is. and Senegal.

Remarks: The dorsal surface and notal margin are uniform red or red brown with irregular areas; the rinophores are red with the tip white; the gills and anal papilla are both uniform white; ventrally the notal margin and foot are white with small red spots.

Internally, our specimens coincide with the descriptions of *D. senegalensis* by BOUCHET (1975) and VALDÉS, ORTEA, ÁVILA AND BALLESTEROS (1996). A complete description and distribution remarks of this species are provide in GARCÍA AND TRONCOSO (in press).

Suborder Aeolidiina Odhner, 1934
Family Facelinidae Bergh in Carus, 1889
Genus *Phidiana* Gray, 1850

Phidiana sp. (Fig. 2M)

Material collected: 17/06/2000; station: Ressurretta (Rata Is.); depth: 14 m; 3 specimens; length: 11 to 17 mm. 18/06/2000; station: Ressurretta (Rata Is.); depth: 12 m; 2 specimens; length: 16-18 mm.

Habitat: On and under stones associated with hydrozoans.

Remarks: The ground colour is reddish with numerous white spots on the dorsal and lateral surfaces of the body; the basal third of the oral tentacles is reddish with white spots, the middle third is orange and the apical third is hyaline white; the foot is reddish; the rhinophores are orange with white tip; the apical surface of cerata are orange, the subapical area are white and the basal part are translucent. A complete description of this species is provided in García and Troncoso (in press).

CONCLUSIONS

We found a total of 111 specimens of . opisthobranchs belonging to 12 species, 1 Cephalaspidea, 1 Anaspidea, 3 Ascoglossa, 2 Notaspidea, 4 Doridacea and 1 Aeolidacea. In Table I the species of Opisthobranchia found up to date in the Archipelago Fernando de Noronha are listed.

Among them, only four species were recorded by Matthews and Kempf (1970): *Micromelo undata* (Bruguière, 1792), *Hydatina vesicaria* (Solander, 1786), *Retusa canaliculata* (Say, 1827) and *Cylichna noronhensis* Watson, 1883. Rios and Barcellos (1979) mentioned the occurrence of *Atys mandrewii* and *Berthelinia caribbea*.

The occurrence of *Elysia ornata*, and *E. flava* are the first records for Brazil.

The Archipelago de Fernando de Noronha does not appear to be as rich in species of opisthobranchs as expected in tropical areas. A big effort is necessary to find species, they are mainly herbivorous and are associated to seaweeds (*Micromelo undata, Stylocheilus longicauda, Elysia ornata, E. flava, Caliphylla mediterranea*).

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A second species of the genus *Plagyostila* (Prosobranchia, Rissooidea) in Senegal, West Africa

Una segunda especie del género *Plagyostila* (Prosobranchia, Rissooidea) en Senegal, Africa Occidental

Emilio ROLÁN* and Jacques PELORCE**

Recibido el 10-IV-2002. Aceptado el 30-V-2002

ABSTRACT

The second species of the genus *Plagyostila* is described. It was found in Dakar, Senegal. Comparison of the shell characters of the new species with those of the type species *P. asturiana* are made.

RESUMEN

Se describe la segunda especie del género *Plagyostila* descubierta en Dakar, Senegal y se comparan los caracteres de la concha de esta nueva especie con los de la especie tipo *P. asturiana*.

KEY WORDS: Rissooidea, *Plagyostila*, new species, West Africa.
PALABRAS CLAVE: *Rissooidea,* Plagyostila, *new species, West Africa.*

INTRODUCTION

Plagyostila asturiana Fischer in de Folin and Périer, 1872 is the only species known up to now for this genus. GOFAS AND PONDER (1991) reviewed this species, the habitat, the distribution range and commented on some anatomical details, showing operculum, radula and protoconch. Its range is known from France (PONDER, 1988), northern Spain (Gijón is the type locality) and north-west Spain (Vigo, in ROLÁN, 1983) to west and north of Morocco (GOFAS AND PONDER, 1991), and Mediterranean (PALLARY, 1920) with an isolated citation in the Cape Verde Islands (BURNAY, 1989).

In the sediment material collected by the junior author in Dakar, Senegal, several shells with a profile similar of that of *P. asturiana* were found, but being different in many characters. These shells appear to belong to an unknown species and is presented in this work and described as new.

RESULTS

Plagyostila senegalensis spec. nov. (Figs. 1-3)

Type material: Holotype (Fig. 1) in MNHN; one paratype (Figs. 2-3) from Gouye Teni M´Both, 25 m, Dakar, Senegal (MNHN); other paratype from Le Tacoma, 15 m, Dakar, Senegal (coll. J. Pelorce);

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one paratype (juvenile) from Le Tacoma, 15 m (MNCN); one paratype from Madeleines, 6-14 m, Dakar, Senegal (coll. E. Rolán).

Other material studied: Senegal: 1 juvenile, Le Tacoma, 15 m (CER).

Type locality: M'Bao, 8.5 m, Dakar, Senegal.

Etymology: The specific name is derived of the country where the species was found.

Description: Shell (Fig. 1) ovate-conic, solid, cream in colour, with an irregular surface, not shinning, somewhat flattened dorsoventrally. Protoconch (Figs. 2, 3) of 2 $^1/_4$ whorls, which present a sculpture of small tubercles on the apical part of the whorls, while there are numerous spiral irregular lines in the abapical part. Teleoconch with about 2 $^1/_2$ whorls, the first one with four spiral cords crossed by orthocline axial ribs, narrower than the intervals, and in number of about 17; in the last whorl, the axial ribs are absent, and the spiral cords are only evident in the subsutural area, almost desappeared in the convexity, and appear again on the abapical area, in a total number of about 12-13. Aperture piriform with a simple outer lip and a columella thickened by a callus.

Dimensions: The holotype and the largest paratype are 2.0 mm high.

Distribution: The species was only found in the Dakar area.

Discussion: The generic assignation was based in the similarity of the present species with the type species of the genus, *P. asturiana*, in the outline, protoconch, and aperture. The presence of six shells with the same characters in several different places of Dakar, confirm us that this is a species with a characteristic morphology. If the habitat is similar to that known for *P. asturiana* (under rocks buried in sand in about 30 cm), it is supposed that it will be very difficult to find frequently material living from sediments.

The species can be differentiated from *P. asturiana* because this latter species is larger (2.3 – 3.0 mm in most of the material referred or examined), the color is milk-white, the external surface is smooth (Fig. 4) with only a subsutural depression, the shell is glossy, the protoconch has a small nucleus (Fig. 5) and the sculpture is reduce to some spiral lines in the lower middle of the whorl (see Gofas and Ponder, 1991, fig. 5). In opposition, *P. senegalensis* is cream in all the shells studied, the larger shell is 2.0 mm, with axial ribs on the first whorl of the teleoconch and few evident spiral cords in subsutural area and on the base. Furthermore, there are differences in the sculpture of the protoconch, numerous spiral lines in the lower part of the whorls and tubercles on the uppert part in *P. senegalensis* and the diameter of its nucleus is larger.

The sculpture of first whorl of teleoconch is similar to some species of the genus *Alvania*, but no other character of this genus is present.

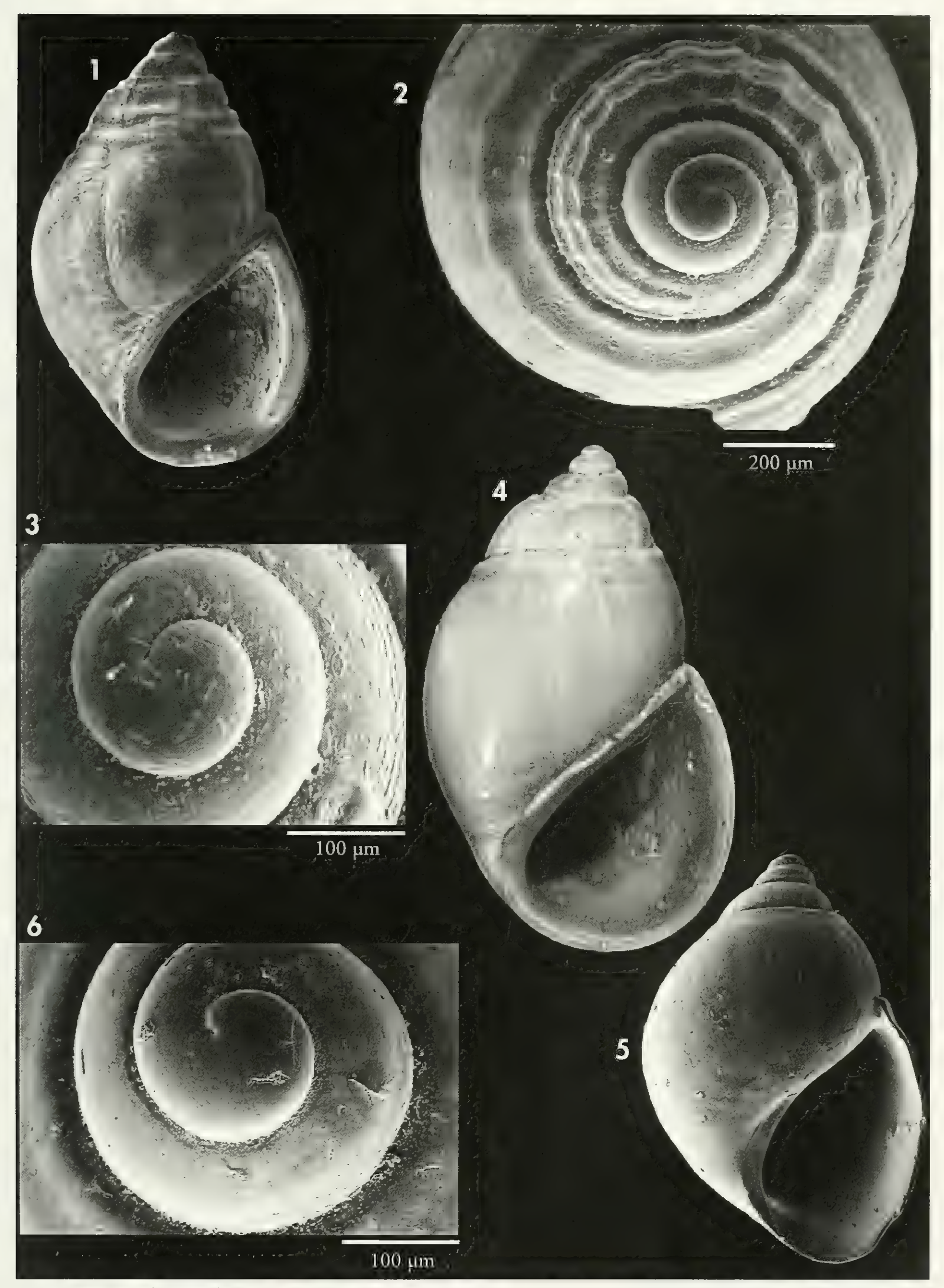
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Figures 1-3. *Plagyostila senegalensis* spec. nov. 1: holotype, 2.0 mm, M'Bao, Dakar (MNHN); 2-3: detail of the spire and protoconch, paratype, Gouye Teni M´Both, Dakar (MNHN). Figures 4-6. *Plagyostila asturiana*. 4: shell from Vigo; 5: juvenile from San Sebastián, Spain; 6: protoconch, San sebastián.

Figuras 1-3. Plagyostila senegalensis *spec. nov. 1: holotipo, 2.0 mm, M'Bao, Dakar (MNHN); 2-3: detalle de la espira y protoconcha, paratipo, Gouye Teni M´Both, Dakar (MNHN). Figuras 4-6.* Plagyostila asturiana. *4: concha de Vigo; 5: juvenil de San Sebastián, España; 6: protoconcha, San Sebastián.*

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La superfamilia *Helicoidea* Rafinesque, 1815 (Gastropoda, Pulmonata, Stylommatophora) en la provincia de Lugo (noroeste de España)

The superfamily *Helicoidea* Rafinesque, 1815 (Gastropoda, Pulmonata, Stylommatophora) in province of Lugo (NW of Spain)

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RESUMEN

El presente trabajo consiste en un estudio faunístico de gasterópodos terrestres pertenecientes a la Superfamilia Helicoidea Rafinesque, 1815, realizado en la provincia de Lugo durante los años 1997-1999. El área de estudio se ha dividido en 130 cuadrículas U.T.M. 10x10 Km, habiéndose recolectado helicoideos en 97 localidades. Teniendo en cuenta nuestros hallazgos y las citas bibliográficas se han elaborado los mapas de distribución de las diferentes especies. Se han identificado un total de 1646 ejemplares correspondientes a 19 especies, ampliándose notablemente el área de distribución conocida de la mayoría de éstas, destacando: *Prietocella barbara* (Linneo, 1758), *Ashfordia granulata* (Alder, 1830), *Ponentina subvirescens* (Bellamy, 1839) y *Oestophora silvae* Ortiz de Zárate, 1962, de las que existían únicamente citas puntuales. Se cita por primera vez para la zona de estudio *Xerotricha apicina* (Lamarck, 1822).

ABSTRACT

A faunistic study of Superfamily Helicoidea Rafinesque, 1815, from province of Lugo (Galicia, Spain) has been made during the years 1997-1999. For each species the previous records and the coordinates U.T.M. 10x10 Km of the localities where the species have been found, are included. 19 species have been identificated and for the most of them, principally *Prietocella barbara* (Linneo, 1758), *Ashfordia granulata* (Alder, 1830), *Ponentina subvirescens* (Bellamy, 1839) and *Oestophora silvae* Ortiz de Zárate, 1962, we have extended notably the distribution area known. *Xerotricha apicina* (Lamarck, 1822) is recorded for the first time in this area.

PALABRAS CLAVE: Gastropoda, Pulmonata, Helicoidea, distribución, Galicia, España.
KEY WORDS: Gastropoda, Pulmonata, Helicoidea, distribution, Galicia, España.

INTRODUCCIÓN

Aunque actualmente contamos con extensos trabajos sobre la fauna malacológica gallega, que han permitido un avance sustancial en su conocimiento, se observan discontinuidades en los datos, tanto en su aspecto faunístico como en la

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distribución de las especies. Esto es debido a que los trabajos previos han consistido en estudios muy amplios, que abarcaban un área muy grande de forma heterogénea, (CASTILLEJO, 1986) o bien en estudios puntuales, en zonas concretas (SACCHI Y VIOLANI, 1977; OUTEIRO, 1988; RIBALLO, DÍAZ-COSÍN, Y CASTILLEJO, 1985). Cabe mencionar que ONDINA, HERMIDA Y OUTEIRO (1997) realizan un estudio en el que se recogen muestras de forma homogénea en un cuadriculado U.T.M. de 10x10 Km, teniendo como objetivo únicamente el occidente gallego, no incluyendo por lo tanto el área tratada en el presente artículo. En esta provincia, hemos de destacar la existencia de dos trabajos realizados en zonas muy concretas como son la Serra do Courel (OUTEIRO, 1988) y el Bosque dos Cabaniños (Serra dos Ancares) (RIBALLO ET AL., 1985) dado que se trata de dos de los escasos afloramientos calizos gallegos y por ello particularmente interesantes.

Estas discontinuidades que se presentan en el conocimiento de la distribución de los gasterópodos terrestres son aplicables por lo tanto a la Superfamilia *Helicoidea*, aún existiendo trabajos específicos sobre el grupo como los de CASTILLEJO (1986) y ONDINA ET AL. (1997).

Con el presente estudio se pretende cubrir algunas de las lagunas existentes referidas al conocimiento de los helicoideos gallegos en su zona más oriental, la provincia de Lugo.

MATERIAL Y MÉTODOS

Durante el período 1997-1999 se ha recolectado material malacológico en la provincia de Lugo procedente de 97 localidades de las 130 cuadrículas U.T.M. 10 x 10 Km en las que se ha dividido dicha área. En cada una de ellas se realizaron muestreos diurnos y nocturnos y se examinaron los distintos hábitats donde suelen resguardarse estas especies. Así mismo se recogieron muestras de suelo y hojarasca que posteriormente fueron lavadas y tamizadas, para extraer las especies edáficas de menor tamaño. Todos los ejemplares capturados se sometieron al proceso de muerte por anoxia, sumergiéndolos en agua para facilitar su disección, conservándose posteriormente en alcohol al 70%.

A partir de los datos obtenidos, se han elaborado mapas de distribución de cada especie en cuadrículas UTM de 10x10 km (Figura 1 A-U). En dichos mapas se indican las localidades aportadas en este trabajo (●); las procedentes de la bibliografía (∆), y aquellas localidades en que ambas citas coinciden (▲).

Para la clasificación de las especies hemos seguido a NORDSIECK (1987, 1993) añadiendo algunas modificaciones, como la de situar el grupo Trissexodontinae Nordsieck, 1987 como una subfamilia de Hygromiidae, de acuerdo con PUENTE (1994).

RESULTADOS

A partir de los muestreos realizados, se han identificado un total de 1646 ejemplares pertenecientes a 19 especies. Para cada especie se incluyen los siguientes apartados: citas previas, material examinado y un breve resumen sobre su distribución. El listado de las localidades en las que se ha encontrado algún ejemplar de esta superfamilia, junto a su correspondiente coordenada U.T.M. y fecha de muestreo, pueden ser observadas en la Tabla I.

Familia XANTHONYCHIDAE Strebel y Pfeiffer, 1880
Subfamilia ELONINAE Gittenberger, 1979

Elona quimperiana (Férussac, 1821) (Fig. 1A)

Citas previas: ALTIMIRA (1969); CASTILLEJO (1986); ALTONAGA, GÓMEZ, MARTÍN, PRIETO, PUENTE Y RALLO (1994); PUENTE (1994).

Material examinado: Localidades 5, 7, 8, 10, 12, 13, 14, 45, 46, 47, 61, 67. Número total de ejemplares: 27.

Distribución. *Elona quimperiana* ocupa toda la cornisa cantábrica desde el País Vasco hasta Asturias (PUENTE, 1994), continuándose esta distribución hacia Galicia, donde es más frecuente en el norte (CAZIOT, 1915; CASTILLEJO, 1986; OTERO Y TRIGO, 1989; ONDINA *ET AL.*, 1997).

Familia HYGROMIIDAE Tryon, 1866
Subfamilia MONACHINAE Wenz, 1930

Ashfordia granulata (Alder, 1830) (Fig. 1B)

Citas previas: CASTILLEJO (1986) como *Monacha (Ashfordia) granulata* (Alder, 1830); ALTONAGA *ET AL.* (1994); PUENTE (1994).

Material examinado: Localidades 4, 6, 7, 8, 9, 12, 13, 14, 15, 16, 18, 19, 28, 29, 32, 46, 49, 52, 54, 57, 76. Número total de ejemplares: 204.

Distribución. Citada únicamente en el norte peninsular, desde el extremo occidental de Vizcaya hasta Galicia (HERMIDA, OUTEIRO Y RODRÍGUEZ, 1992; ALTONAGA *ET AL.*, 1994; PUENTE, 1994) donde, al igual que la especie anterior, es más frecuente en la mitad norte (MACHO VELADO, 1871; HIDALGO, 1875; CASTILLEJO, 1986; ONDINA *ET AL.*, 1997).

Cochlicella acuta (Müller, 1774) (Fig. 1C)

Citas previas: CASTILLEJO (1986).

Material examinado: Localidades 12, 14, 16, 19. Número total de ejemplares: 18.

Distribución. Es una especie frecuente en toda la costa peninsular, haciéndose sus citas más escasas en el cuadrante noroeste (PUENTE, 1994). Aunque penetra hacia zonas del interior siguiendo las cuencas fluviales, como el valle del Ebro o el del Guadalquivir, en Galicia se comporta como una especie estrictamente litoral (HIDALGO, 1875; CASTILLEJO, 1986; ONDINA *ET AL.*, 1997).

Prietocella barbara (Linneo, 1758) (Fig. 1D)

Citas previas: ALTIMIRA (1969), como *C. ventricosa* (Draparnaud, 1801); CASTILLEJO (1986), como *C. ventricosa*.

Material examinado: Localidades 3, 4, 12, 14, 15, 16, 18, 19, 21, 40, 41, 42, 46, 48, 49, 52, 53, 54, 55, 79, 90, 91, 94, 95. Número total de ejemplares: 151.

Distribución. Esta especie presenta una amplia distribución por toda la península y aunque está citada en casi todos los estudios malacológicos realizados a lo largo del territorio, es más frecuente en la franja litoral (MARTÍNEZ-ORTÍ, MARTÍNEZ-LÓPEZ, ROBLES CUENCA Y RODRÍGUEZ BABÍO, 1990; HERMIDA *ET AL.*, 1992; PUENTE, 1994). Aunque en el occidente gallego su comportamiento es igualmente costero (CASTILLEJO, 1986; OTERO Y TRIGO, 1989; ONDINA *ET AL.*, 1997), en el área de estudio se adentra claramente hacia el interior.

Subfamilia TRISSEXODONTINAE Nordsieck, 1987

Oestophora barbula (Rossmässler, 1838) (Fig. 1E)

Citas previas: ALTIMIRA (1969); RIBALLO *ET AL.* (1985); CASTILLEJO (1986); CASTILLEJO, RIBALLO Y DÍAZ-COSÍN (1987); OUTEIRO (1988); ALTONAGA *ET AL.* (1994); PUENTE (1994).

Material examinado: Localidades 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 23, 24, 31, 32, 33, 36, 37, 38, 39, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 59, 60, 61, 63, 64, 66, 67, 69, 73, 76, 77,

78, 80, 81, 82, 83, 84, 85, 86, 90, 91, 92, 93, 94, 95. Número total de ejemplares: 300.
Distribución. Especie atlántica, muy frecuente en todo el tercio occidental peninsular (NOBRE, 1941; HERMIDA *ET AL*., 1992; PUENTE, 1994). Del mismo modo en Galicia está ampliamente citada en todo el territorio (CASTILLEJO, 1986; ONDINA, *ET AL*., 1997).

Oestophora silvae Ortiz de Zárate, 1962 (Fig. 1F)

Citas previas: ALTIMIRA (1969); CASTILLEJO (1986); OUTEIRO (1988); ALTONAGA *ET AL*. (1994);. PUENTE (1994).

Material examinado: Localidades 1, 10, 12, 13, 23, 27, 28, 30, 33, 35, 36, 37, 39, 41, 42, 43, 45, 47, 51, 52, 53, 54, 55, 57, 58, 59, 61, 64, 66, 67, 68, 69, 78, 80, 82, 84, 85, 86, 88, 89, 90, 92, 93, 95. Número total de ejemplares: 140.

Distribución. En la Península Ibérica esta especie está citada únicamente en la franja norte, desde el País Vasco hasta Galicia (CASTILLEJO, 1986; PUENTE, 1994; ONDINA *ET AL*., 1997), descendiendo por el oeste de Portugal (HERMIDA Y RODRÍGUEZ, 1996). Hasta el momento en la provincia de Lugo estaba citada únicamente en puntos aislados del norte y en la sierra de O Courel (OUTEIRO, 1988), confirmándose con este trabajo su amplia distribución en Galicia.

Oestophorella buvinieri (Michaud, 1841) (Fig. 1G)

Citas previas: ALTIMIRA (1969); ALTONAGA *ET AL*. (1994).

Material examinado: Localidades 10, 18. Número total de ejemplares: 5.

Distribución. *Oestophorella buvinieri* es un endemismo cantábrico que se extiende desde el occidente del País Vasco hasta Galicia (ALTONAGA *ET AL*., 1994; PUENTE, 1994), alcanzándose en el área de estudio su límite de distribución oriental con las dos citas del presente trabajo.

Subfamilia HYGROMIINAE Tryon, 1866

Candidula intersecta (Poiret, 1801) (Fig. 1H)

Citas previas: ALTIMIRA (1969); CASTILLEJO (1986).

Material examinado: Localidad 14. Número total de ejemplares: 4.

Distribución. En la Península Ibérica presenta una distribución particular, ya que se encuentra citada en el tercio occidental y, alejada de este área de distribución, en el País Vasco (PUENTE, 1994). En Galicia es más característica en la franja oeste y sus citas se van haciendo más raras a medida que avanzamos hacia el norte (ONDINA *ET AL*., 1997); en el área de estudio ha aparecido únicamente y hasta el momento en tres localidades.

Xerotricha apicina (Lamarck, 1822) (Fig. 1I)

Material examinado: Localidad 13. Número total de ejemplares: 2.

Distribución. Especie con una distribución muy fragmentada, concentrándose sus citas principalmente en el cuadrante suroccidental de la península (NOBRE, 1941; PUENTE, 1994), en el litoral catalán (BOFILL Y HAAS, 1920a; BOFILL Y HAAS, 1920b) y en las islas Baleares (GASULL, 1965). En Galicia está escasamente representada, con citas aisladas en el litoral (SACCHI Y VIOLANI, 1977; CASTILLEJO, 1986; ONDINA *ET AL*., 1997). Se trata de la primera cita de esta especie para el área de estudio.

Tabla I. Listado de las localidades, U.T.M. en 10x10 Km y fecha de recogida de las muestras.
Table I. List of the localities, U.T.M. 10 x10 Km and sampling date.

Localidad	U.T.M.	Fecha	Localidad	U.T.M.	Fecha
1 Vilapedre	29TPJ00	24/07/97	50 Fonteo	29TPH46	29/05/98
2 Moreda	29TPJ10	25/07/97	51 Portomarín	29TPH14	30/05/98
3 Galgao	29TPJ20	25/07/97	52 Neira	29TPH24	30/05/98
4 Riotorto	29TPJ40	25/07/97	53 Ferreira de Pallares	29TPH04	30/05/98
5 Maior	29TPJ30	25/07/97	54 Vilarmide	29TPH49	31/05/98
6 Requerez	29TPJ12	26/07/97	55 Piñeira	29TPH44	06/06/98
7 Galdo	29TPJ13	26/07/97	56 Farreiros	29TPH45	06/06/98
8 Xuances	29TPJ14	26/07/97	57 Láncara	29TPH34	06/06/98
9 Mor	29TPJ22	27/07/97	58 Suar	29TPH13	07/06/98
10 Rúa (Oirás)	29TPJ21	27/07/97	59 Bagude	29TPH03	07/06/98
11 O Marco	29TPJ23	27/07/97	60 A Pobra de Burón	29TPH57	22/07/98
12 Teixeira	29TPJ32	28/07/97	61 Trobo	29TPH58	22/07/98
13 Alemparte	29TPJ33	28/07/97	62 Vilarmeán	29TPH68	22/07/98
14 Morás	29TPJ24	28/07/97	63 Seir	29TPH78	23/07/98
15 Masma	29TPJ31	29/07/97	64 Negueira de Muñiz	29TPH77	23/07/98
16 Reinante	29TPJ42	29/07/97	65 Vilabol	29TPH67	23/07/98
17 As Anzas	29TPJ51	30/07/97	66 Castro (Moreira)	29TPH56	24/07/98
18. Arante	29TPJ41	30/07/97	67 Queizán	29TPH66	24/07/98
19 Ribadeo	29TPJ52	31/07/97	68 Cabanas	29TPH55	24/07/98
20 Bazar	29TPH28	15/12/97	69 Navia-Moia	29TPH65	25/07/98
21 Roca	29TNH98	13/02/98	70 Rao-Faquis	29TPH75	25/07/98
22 Parga	29TNH97	13/02/98	71 Suarbol, Piornedo	29TPH74	25/07/98
23 Pígara	29TPH08	14/02/98	72 Doiras, Cervantes	29TPH64	25/07/98
24 Vilalba	29TPH09	14/02/98	73 Becerreá	29TPH54	25/07/98
25 Cazás	29TNH99	14/02/98	74 Busnollán	29TPH53	26/07/98
26 Vilalba-Meira	29TPH19	15/02/98	75 Pedrafita- Doiras	29TPH63	26/07/98
27 Moncelos	29TPH29	15/02/98	76 Triacastela	29TPH43	26/07/98
28 Gruñedo	29TPH38	15/02/98	77 Foxos, Samos	29TPH33	26/07/98
29 Outeiro-Quintela	29TPH28	16/02/98	78 Biville	29TPH23	27/07/98
30 Vián	29TPH39	16/02/98	79 Chantada- Mato	29TNH91	05/04/99
31 Porto	29TPH18	15/02/98	80 Sabadelle	29TPH02	05/04/99
32 Begonte	29TPH07	16/02/98	81 Chantada	29TPH01	06/04/99
33 Outeiro de Rei	29TPH17	16/02/98	82 R. Portiño- Ousende	29TPH12	06/04/99
34 Orizón	29TPH27	17/02/98	83 Tribas	29TPH11	06/04/99
35 Condes	29TNH96	18/02/98	84 Oleiros	29TPH00	07/04/99
36 Ferreira	29TNH95	18/02/98	85 Fonte A. (Pantón)	29TPH10	07/04/99
37 Guntín	29TNH94	18/02/98	86 Barantes	29TPG19	07/04/99
38 Lugo-Camoira	29TPH16	19/02/98	87 Saa (Pobra Brollón)	29TPH31	08/04/99
39 Cotá	29TPH06	19/02/98	88 Doade	29TPG29	08/04/99
40 Gondar	29TPH26	19/02/98	89 Marcelle	29TPH20	08/04/99
41 Anseán	29TPH25	20/02/98	90 Goo (Río Mao)	29TPH32	09/04/99
42 Outeiro	29TPH15	20/02/98	91 Barxa (Río Mao)	29TPH22	09/04/99
43 Gundín-Friol	29TPH05	20/02/98	92 Ribas Pequenas	29TPH21	09/04/99
44 Riveira de Piquín	29TPH48	03/04/98	93 Paradapiñol	29TPH50	10/04/99
45 Bogo	29TPH59	02/04/98	94 Quiroga	29TPH40	10/04/99
46 Mosteiro	29TPH37	28/05/98	95 Augasmestas	29TPH30	10/04/99
47 Mendreiras	29TPH47	28/05/98	96 Carbedo	29TPH52	10/04/99
48 Sobrado	29TPH35	29/05/98	97 A Rogueira	29TPH51	10/04/99
49 Castroverde	29TPH36	29/05/98			

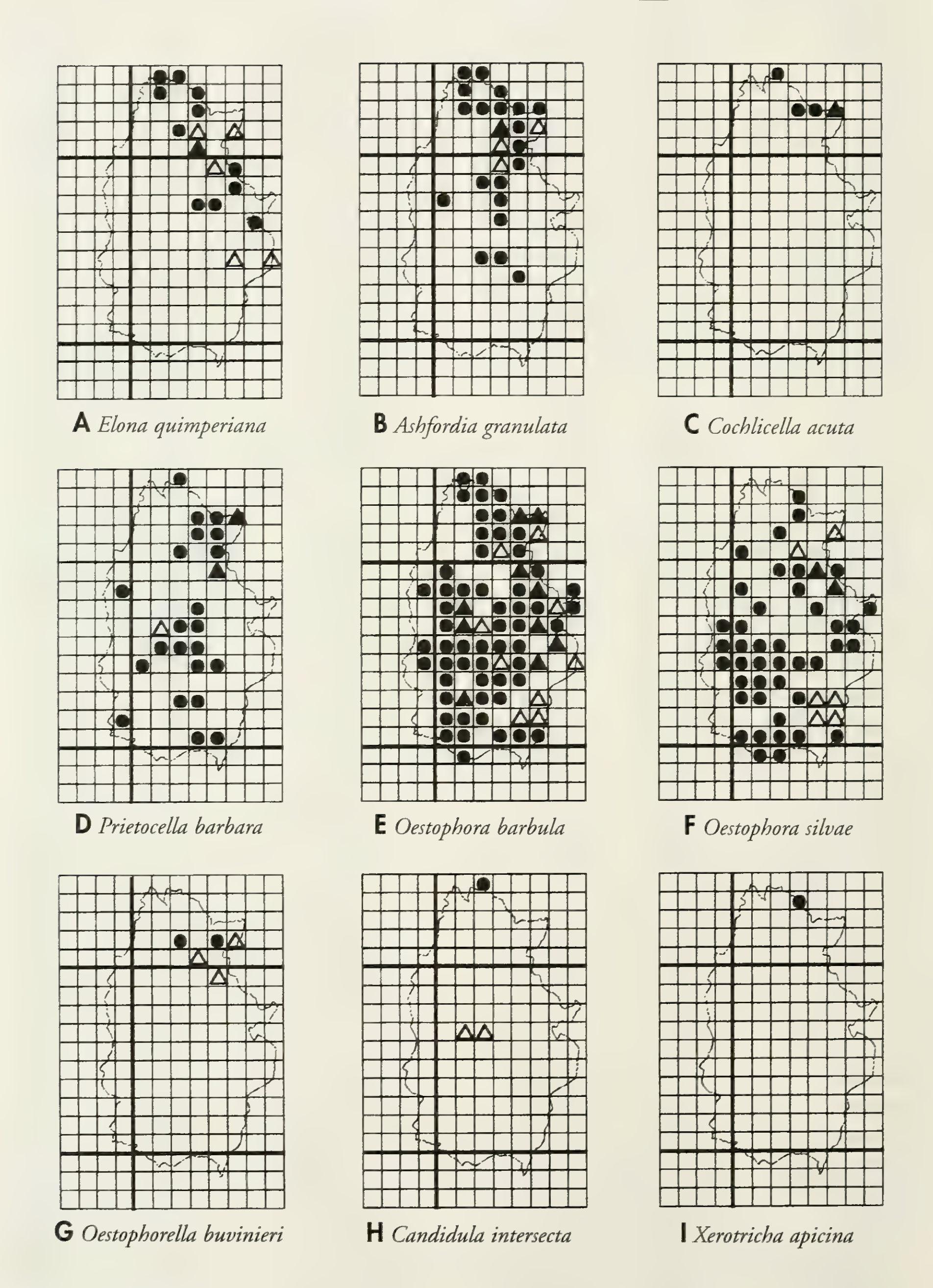
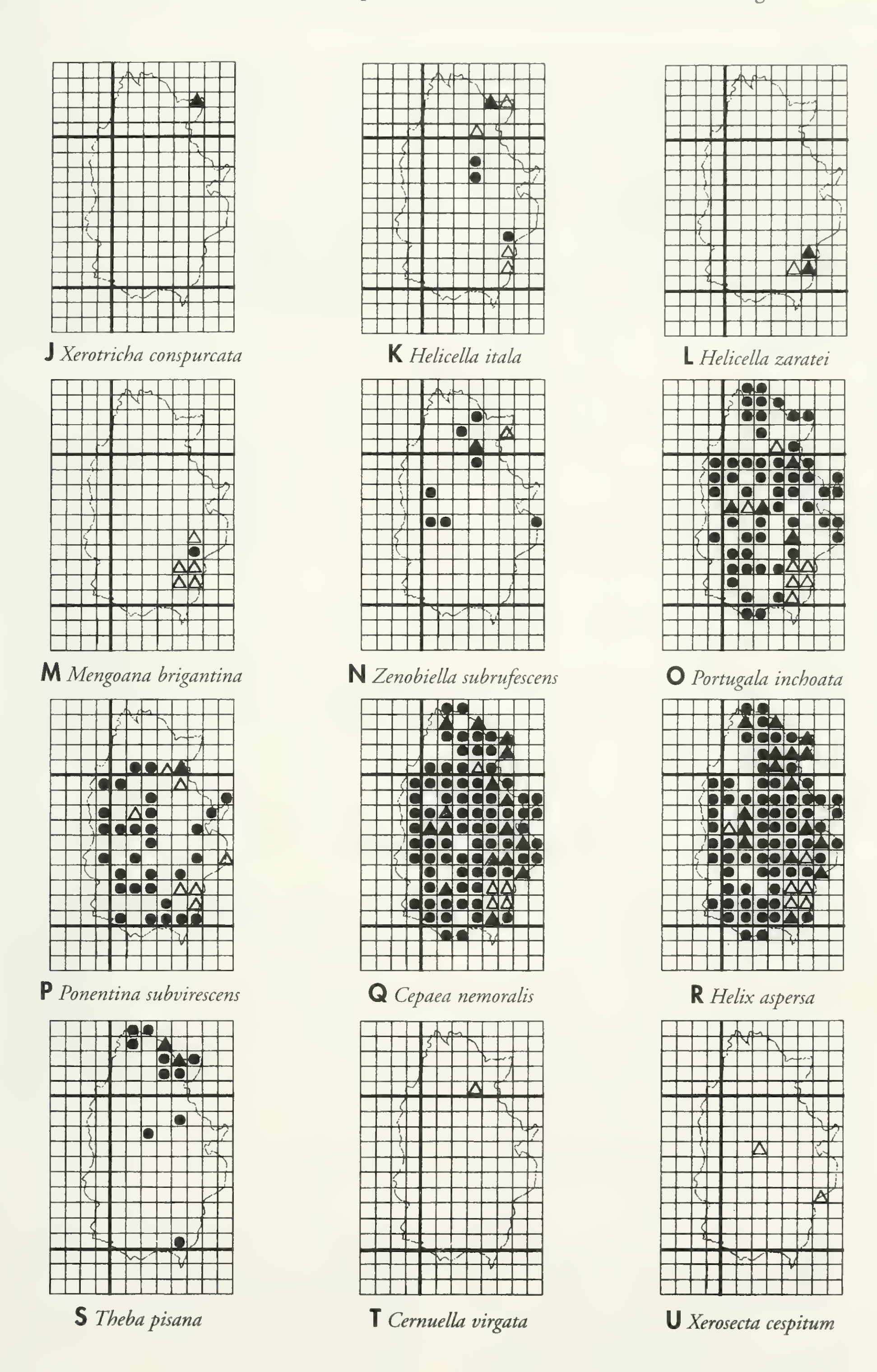


Figura 1. Mapas de distribución.
Figure 1. Distribution maps.



J *Xerotricha conspurcata* **K** *Helicella itala* **L** *Helicella zaratei*

M *Mengoana brigantina* **N** *Zenobiella subrufescens* **O** *Portugala inchoata*

P *Ponentina subvirescens* **Q** *Cepaea nemoralis* **R** *Helix aspersa*

S *Theba pisana* **T** *Cernuella virgata* **U** *Xerosecta cespitum*

Xerotricha conspurcata Draparnaud, 1801 (Fig. 1J)

Citas previas: ONDINA, HERMIDA Y OUTEIRO (1995).

Material examinado: Localidad 19. Número total de ejemplares: 2.

Distribución. Esta especie se distribuye por la mitad sur peninsular y el litoral catalán (PUENTE, 1994). La localidad aportada en este trabajo representa la única cita de la mitad noroccidental de la Península, donde fue encontrada por primera vez por ONDINA *ET AL.* (1995). Se ha encontrado una población con muy pocos individuos, muy alejada de su área de distribución, por lo que es posible, que de acuerdo con los autores antes mencionados, se trate de una introducción bastante reciente.

Helicella itala (Linneo, 1758) (Fig. 1K)

Citas previas: CASTILLEJO (1986); OUTEIRO (1988).

Material examinado: Localidades 16, 28, 46, 74. Número total de ejemplares: 13.

Distribución. Esta especie se extiende por la mitad norte peninsular (MANGA, 1983; HERMIDA *ET AL.*, 1992; ALTONAGA *ET AL.*, 1994; PUENTE, 1994). En Galicia se comporta principalmente como una especie litoral, también confinada al norte, provincias de A Coruña y Lugo (CASTILLEJO, 1986, ONDINA *ET AL.*, 1997).

Helicella zaratei Gittenberger et Manga, 1977 (Fig. 1L)

Citas previas: OUTEIRO (1988).

Material examinado: Localidades 96, 97. Número total de ejemplares: 2.

Distribución. *Helicella zaratei* es un endemismo galaico-leonés, citada únicamente en algunos puntos de León (MANGA, 1983). En Galicia parece estar restringida a los afloramientos calizos de la Sierra do Courel (OUTEIRO, 1988).

Mengoana brigantina (da Silva Mengo, 1867) (Fig. 1M)

Citas previas: CASTILLEJO (1986) como *Eumphalia (Mengoana) brigantina* (Ortiz de Zárate, 1949) OUTEIRO (1988) como *Eumphalia (Mengoana) brigantina*.

Material examinado: Localidad 74. Número total de ejemplares: 10.

Distribución. Endemismo ibérico restringido al noroeste de la Península (HIDALGO, 1875; CASTILLEJO, 1986; HERMIDA *ET AL.*, 1992; PUENTE Y PRIETO, 1992). En Galicia está citada en puntos aislados del litoral occidental (ONDINA *ET AL.*, 1997), mientras que en el área de estudio parece circunscribirse a la zona de O Courel (CASTILLEJO, 1986; OUTEIRO, 1988), caracterizada por ser uno de los escasos afloramientos calizos gallegos.

Zenobiella subrufescens (Miller, 1822) (Fig. 1N)

Citas previas: CASTILLEJO (1986); ALTONAGA *ET AL.* (1994); PUENTE (1994).

Material examinado: Localidades 5, 10, 12, 30, 32, 42, 43, 70. Número total de ejemplares: 34.

Distribución. Esta especie está restringida al norte peninsular, sin alejarse de la franja litoral (ALTONAGA *ET AL.*, 1994; PUENTE, 1994). En Galicia sus citas se concentran principalmente en la mitad norte (CASTILLEJO, 1986; ONDINA *ET AL.*, 1997). Las escasas citas previas de esta especie en el área de estudio se sitúan en la franja litoral.

Portugala inchoata (Morelet, 1845) (Fig. 1O)

Citas previas: ALTIMIRA (1969) como *Z. inchoata* (Morelet, 1845); CASTILLEJO (1986); OUTEIRO (1988).

Material examinado: Localidades 4, 6, 7, 8, 9, 10, 11, 13, 14, 16, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 33, 37, 39, 40, 41, 43, 44, 45, 46, 47, 49, 51, 52, 54, 55, 56, 58, 59, 61, 63, 64, 65, 66, 69, 70, 71, 76, 80, 81, 82, 85, 86, 88, 90, 91, 95. Número total de ejemplares: 144.

Distribución. Especie atlántica ampliamente distribuida por toda la franja occidental de la Península Ibérica (NOBRE, 1941; HERMIDA *ET AL.*, 1992; PUENTE, 1994). En Galicia es una especie muy abundante y citada en la mayoría de los estudios sobre la malacofauna de esta comunidad (MACHO VELADO, 1871; HIDALGO, 1875; CASTILLEJO, 1986; OTERO Y TRIGO, 1989; ONDINA *ET AL.*,1997).

Subfamilia PONENTININAE Schileyko, 1991

Ponentina subvirescens (Bellamy, 1839) (Fig. 1P)

Citas previas: ALTIMIRA (1969) como *Trichia occidentalis* (Récluz); RIBALLO *ET AL.* (1985) como *Ponentina ponentina* (Morelet, 1845); CASTILLEJO (1986) como *P. ponentina;* OUTEIRO (1988) como *P. ponentina*.

Material examinado: Localidades 2, 3, 4, 22, 24, 25, 29, 34, 35, 37, 38, 39, 40, 41, 51, 59, 63, 65, 66, 73, 76, 78, 80, 82, 84, 87, 89, 91, 93, 94, 95. Número total de ejemplares: 69.

Distribución. Está bien representada en el occidente peninsular (NOBRE, 1941; MANGA, 1983; HERMIDA *ET AL.*, 1992; PUENTE Y PRIETO, 1992) así como en Galicia (HIDALGO, 1875; CASTILLEJO, 1986; ONDINA *ET AL.*, 1997). Hasta el presente estudio era una especie citada de forma aislada en la provincia de Lugo.

Familia HELICIDAE Rafinesque, 1815.
Subfamilia HELICINAE Rafinesque, 1815

Cepaea nemoralis (Linneo, 1758) (Fig. 1Q)

Citas previas: MACHO VELADO (1871) como *Helix nemoralis* Linné; HIDALGO (1875) como *H. hortensis*, O.F. Müller, 1774; ALTIMIRA (1969); CASTILLEJO (1986); OUTEIRO (1988); ALTONAGA *ET AL.* (1994); PUENTE (1994).

Material examinado: Localidades 1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 90, 91, 92, 93, 94, 95. Número total de ejemplares: 275

Distribución. En la Península Ibérica se extiende por la franja portuguesa (HIDALGO, 1875; NOBRE, 1941) y toda la mitad norte (ALTONAGA *ET AL*, 1994; PUENTE, 1994). En Galicia es una especie muy frecuente en toda la comunidad (CASTILLEJO, 1986; ONDINA *ET AL.*, 1997).

Helix aspersa (Müller, 1774) (Fig. 1R)

Citas previas: ALTIMIRA (1969); CASTILLEJO (1986); OUTEIRO (1988); ALTONAGA *ET AL.* (1994).

Material examinado: Localidades 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 59, 60, 61, 62, 63, 64, 66, 67, 68, 69, 70, 72, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85,

86, 87, 88, 89, 90, 92, 93, 94, 95. Número total de ejemplares: 194.

Distribución. *Helix aspersa* es una especie muy frecuente en todo el territorio peninsular (ALTONAGA *ET AL.*, 1994; PUENTE, 1994) así como en Galicia (CASTILLEJO, 1986; ONDINA *ET AL.*; 1997).

Theba pisana (Müller, 1774) (Fig. 1S)

Citas previas: ALTIMIRA (1969); CASTILLEJO (1986).

Material examinado: Localidades 7, 8, 12, 13, 14, 15, 16, 18, 19, 34, 44, 94. Número total de ejemplares: 52.

Distribución. Especie que se distribuye por todo el litoral ibérico, mitad sur peninsular y valle del Ebro (HIDALGO, 1875; NOBRE, 1941; GASULL, 1965; PUENTE, 1994). En Galicia se halla presente a lo largo de toda la costa (MACHO VELADO, 1871; HIDALGO, 1890; ALTIMIRA, 1969; SACCHI Y VIOLANI, 1977; CASTILLEJO, 1986; OTERO Y TRIGO, 1989; ONDINA *ET AL.*, 1997).

DISCUSIÓN

El hecho de que en la provincia de Lugo se encuentren algunos de los afloramientos calizos más importantes de la comunidad gallega, y de que se trataba de un área poco estudiada, abría la posibilidad de que presentase diferencias sustanciales, en referencia a su fauna malacológica, en comparación a otras áreas de Galicia. En el número de especies encontradas no destaca respecto al resto de Galicia, aunque sí existen mayor número de endemismos. En este sentido el número de especies de la superfamilia Helicoidea no presenta diferencias sustanciales con el resto de la comunidad gallega, aunque habría que mencionar que en esta provincia se encuentra el límite de distribución occidental de algunas especies.

Cabe destacar que se cita por primera vez en el área de estudio *X. apicina*, especie de muy reducida presencia en Galicia. Así mismo se ha ampliado el área de distribución conocida de un número notable de especies, incluso de aquellas más frecuentes en el área de estudio, pero que por los motivos citados estaban escasamente representadas, como *H. aspersa*, *C. nemoralis*, *O. barbula*, o *P. inchoata*. Entre las especies que parecían estar restringidas a puntos aislados del área de estudio y que han pasado a ser frecuentes cabe destacar *A. granulata*, *P. subvirescens*, *O. silvae* y *P. barbara*. En referencia a esta última, que presenta un comportamiento costero en el occidente gallego (ONDINA *ET AL*, 1997), en este trabajo se observa que penetra de forma clara hacia el interior, continuándose su distribución con las zonas colindantes de Asturias y León (MANGA, 1983; HERMIDA *ET AL.*, 1992; PUENTE, 1994).

En contraposición a los grupos anteriores existen otras especies que parecen limitarse a zonas concretas. En este sentido cabe mencionar que en lo que respecta a *O. buvinieri* y *H. zaratei*, se ratifica que el límite de distribución occidental se encuentra en la provincia de Lugo, en el noreste para la primera y en el afloramiento calizo de O Courel para la segunda. Observando la figura 1M vemos que algo similar ocurre con *M. brigantina*, que únicamente se localiza en O Courel, aunque existen citas aisladas en el litoral occidental (ONDINA *ET AL.*, 1997). Esto probablemente es debido a que su distribución, como la de la mayoría de los helicoideos, se ve muy influenciada por los requerimientos de calcio, disponible en las zonas costeras en forma de sales. Este mismo comportamiento se puede observar claramente en especies como *H. itala* o *T. pisana*, estrictamente litorales en el resto de Galicia (ONDINA *ET AL.*, 1997).

En lo que respecta a *C. intersecta*, una especie con escasa representación en el área de estudio, y coincidiendo con lo señalado por CASTILLEJO (1986), pre-

senta variaciones de la parte masculina del aparato genital. Concretamente, la longitud del flagelo respecto al conjunto pene-epifalo en los ejemplares encontrados, es superior al descrito por otros autores. Carecemos de material suficiente para realizar un estudio profundo del tema, pero no podemos descartar la existencia de una especie diferente, hecho señalado por algunos autores (ORTIZ DE ZÁRATE, 1991; PUENTE, 1994; ALTABA, 1997).

Finalmente, creemos oportuno incluir los mapas de distribución de dos especies que han sido citadas en el área de estudio por otros autores y no fueron encontradas en el presente trabajo (Figuras 1T y 1U). *Cernuella virgata* (Da Costa, 1778), común en la Península Ibérica, se convierte en Galicia en una especie rara, ya que se ha encontrado en un único punto de la provincia de Lugo (CASTILLEJO, 1986). *Xerosecta cespitum* (Draparnaud, 1801) ha sido citada únicamente en dos localidades (PUENTE, 1994 y ONDINA *ET AL.*, 1995) muy próximas a los límites occidentales de su amplia área de distribución.

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The degradation of land snail shells during the annual dry period in a Mediterranean climate

La degradación de las conchas de moluscos terrestres durante el período seco anual en un clima mediterráneo

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ABSTRACT

The shell degradation of eight common Mediterranean land mollusc species was experimentally investigated during the annual dry period (June to September). The results suggest that insolation was an important factor in degradation but that the background coloration of the support on which the shells were attached was not a significant factor. Larger species degraded less rapidly than smaller ones. *Cantareus aspersus* (Müller, 1774) took the longest time to degrade, possibly because the periostracum protects the underlying shell. A shell Condition Index is used that allows the scoring of shells and their inclusion or not in species matrices.

RESUMEN

La degradación de las conchas de ocho especies de moluscos terrestres comunes en el Mediterráneo fue investigada experimentalmente durante el período anual de sequía (Junio a Septiembre). Los resultados sugieren que la insolación constituye un factor importante en la degradación, pero que el color de fondo del emplazamiento donde los moluscos estaban fijados no era un factor significativo. Las especies de mayor tamaño se degradaron más lentamente que las pequeñas. *Cantareus aspersus* (Müller, 1774) fue la más lenta en degradarse, posiblemente debido al periostraco que protege la concha. Un Indice del estado de la concha se utiliza para calificar las conchas y su inclusión, o no, en las matrices de especies.

KEY WORDS: Land snail shells, degradation, Mediterranean climate
PALABRAS CLAVE: Conchas de moluscos terrestres, degradación, clima Mediterráneo

INTRODUCTION

'How long has that shell been empty?' This is a question most collectors ask when picking up an empty snail shell. For a collector the answer may not be critical: as long as the shell is in good condition it may be added to the collection. For the ecologist, using standardized data collection techniques (MENEZ, 2001; 2002), the answer is much more pertinent. If the shell is very recent it

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indicates an individual that, until death, utilized resources, interacted with biotic and abiotic components, and formed part of the molluscan biomass. These facts are also true of an older shell but the difference is in the time elapsed from death to recording of the shell by the investigator. In the former case, contemporary biotic and abiotic data may apply to the specimen; in the latter it may not because conditions may have changed significantly from the time of death of the specimen to the recording of data. Dead shells are often included in species matrices used in diversity studies (NILSSON, BENGTSSON AND AS, 1988; WINTER, 1995; EMBERTON, 1997; EMBERTON, PEARCE, KASIGWA, TATTERSFIELD AND HABIBU, 1997), but often with no indication of shell condition. A knowledge of the elapsed period since death is crucial in the inclusion or not of the specimen in the species matrix for an area under ecological study.

Species matrices composed of abundances are affected by the inclusion of dead shells in a quantitative manner for the species recorded. Species matrices composed only of presence/absence data may reflect lower species numbers for an area if only species found as live specimens are included. This is particularly true if substratum samples are analyzed for micro-species that often are only found dead. Examples of these species are *Truncatellina cylindrica*, *Cecilioides acicula* and *Acicula* spp., the last of which are mostly known only from dead specimens.

Some of the factors that contribute to shell degradation are known (e.g. pH, humidity) and have been reported (EVANS 1972; CLAASSEN, 1998) but there is much scope for experimental, and consequently objective, study of shell degradation. In this paper I examine one major factor in degradation that is particularly relevant in Mediterranean regions: insolation. My fieldwork during many years suggests that shells on open ground degrade rapidly during the dry period of the year (unpublished data). In the Mediterranean this period is generally from June to September (BLONDEL AND ARONSON, 1999) and coincides with decreased, or cessation of activity of most land molluscs.

Data collection for diversity and distributional studies are carried out during the wet period (October to May) when mollusc activity is pronounced. Should empty shells found during this period be included in the species matrices? To help answer this I exposed the shells of eight species to the sun during the dry period and measured shell degradation.

METHODS

Forty live adult specimens of each of eight common land mollusc species were collected from sites in south Iberia: *Ferussacia follicula* (Gmelin, 1790) and *Otala lactea* (Müller, 1774) from Westside (Gibraltar); *Xerotricha apicina* (Lamarck, 1822), *Cochlicella acuta* (Müller, 1774) and *Caracollina lenticula* (Michaud, 1831) from Catalan Bay (Gibraltar); *Rumina decollata* (Linnaeus, 1758) from Marbella (Spain); *Theba pisana* (Müller, 1774) from Casares (Spain) and *Cantareus aspersus* (Müller, 1774) from both Marbella and Casares (Spain). The experimental layout consisted of two wooden boards each divided equally in two. One half was painted white and the other black, to test effects of background coloration. Ten shells of each species with the animals removed were attached, aperture downwards, to the two halves of each of the two boards using Blu-Tack®. The adhesive was attached at the midline of the shell leaving a space of 2mm between the shell and the board. Both of the boards were placed on a roof terrace, in Gibraltar, receiving sunlight from sunrise until sunset. One was exposed to the sun, the other was kept in darkness as a control.

The condition of each shell was scored using a simple index (SCI, see Table I) every three days. Scoring began on 1 June 2000 and ended on 2 October 2000 (124 days), representing the dry period (see Introduction). Temperature (°C), total rainfall (mm) and total suns-

Table I. Shell Condition Index (SCI) showing descriptions of shell condition for each score.
Tabla I. Indice del estado de la concha (SCI) con descripción de estado para cada valor.

Score	Description of shell condition
1	Perfect shell. No loss of gloss. Periostracum intact. No shell damage
2	<10% loss of gloss. <10% lifting of periostracum. <1% area of shell damaged
3	10-50% loss of gloss. 10-50% lifting of periostracum. 1-5% area of shell damaged
4	50-75% loss of gloss. 50-75% lifting of periostracum. >5% area of shell damaged
5	75-95% loss of gloss. 75-95% lifting, or loss, of periostracum. >5% area of shell damaged
6	Total loss of gloss. Total loss of periostracum. >5% area of shell damaged
7	As score 6 but shell brittle

hine (hours) data were provided courtesy of the Gibraltar Meteorological Office. Values for these variables during the experimental period were within the ranges for the 30-year data set from 1968 to 1997 (Table II).

Each of the species were assigned to a geometric type and biometric data measured (Table III). *X. apicina* and *C. lenticula* were designated discoidal, *F. follicula* and *R. decollata* cylindrical, *C. aspersus*, *O. lactea* and *T. pisana* spherical, and *C. acuta* conical. Shell height and width, and apertural height and width were measured with calipers to 0.01mm. Shell volume and surface area were calculated using geometric formulae (VAN STIGT, 1974).

RESULTS

The time, in days, that 50% and 100% of shells attained each of the SCI scores is shown in Table IV. All shells were scored SCI 2 at the beginning of the experiment because perfect shells were not obtained after killing and removing the animals. There was no significant difference between the white and black sides of the board for any of the species (paired samples t-tests: *F.*

Table II. Monthly mean temperature, total rain and total sunshine for the experimental period, and ranges for the same months from a 30-year data set (1968-1997). Data courtesy of the Gibraltar Meteorological Office.
Tabla II. Medias mensuales de temperatura, lluvia total y horas de sol para el periodo de experimentación, y rangos para los mismos meses para un periodo de 30 años (1968-1997). Datos por cortesía del Gibraltar Meteorological Office.

Month/year	Mean temperature (°C)	Total rain (mm)	Total sunshine (hours)
June 2000	22.8	0	308
July 2000	23.4	0	334
August 2000	23.8	0	304
September 2000	22.7	9	225
Ranges 1968-1997			
June	17.4-25.0	0-147	264-358
July	19.7-27.7	0-8	276-368
August	20.4-28.3	0-135	258-361
September	19.2-26.0	0-119	194-306

Table III. Biometric data (mm) for all species (n= 40 for each species) showing mean, standard deviation and range for each.
Tabla III. Datos biométricos (mm) para todas especies (n= 40 para cada especie) con media, desviación estándar y rango para cada una.

Species	Height	Width	Volume	Surface area	Apertural area
F. follicula	8.53±0.52	3.48-0.19	81.54±13.47	112.38±12.20	7.94±1.10
	7.4-9.6	3.2-4.0	63.32-120.69	93.86-145.83	5.78-10.35
R. decollata	23.56±3.05	9.71±0.73	1783.76±533.03	873.64±171.36	44.48±10.60
	18.8-33.9	8.3-12.6	1055.49-4228.69	616.93-1591.92	26.13-91.02
X. apicina	3.99±0.60	6.14±1.16	127.74±65.35	134.48±50.12	9.19±2.43
	2.4-5.2	4.2-8.9	26.49-304.96	23.47-261.53	5.25-15.21
C. acuta	12.69±0.92	5.07±0.36	86.22±15.77	118.04±15.49	10.57±2.12
	10.8-14.7	4.3-5.7	54.76-116.46	85.05-147.36	7.14-17.94
C. aspersus	28.51±2.31	30.35±2.50	9221.84±2349.76	2113.28±348.30	362.99±65.11
	25.2-34.9	26.4-38.1	5966.52-17325.61	1591.07-3238.43	255.78-540.54
O. lactea	21.18±1.26	28.99±3.05	6058.84±1039.02	1601.75±190.91	173.03±23.05
	18.3-24.5	16.9-32.5	3004.23-7989.66	1007.00-1932.98	126.69-232.44
T. pisana	12.25±0.93	16.82±1.42	1743.18±586.05	677.28±92.25	70.27±11.01
	10.1-14.7	12.8-20.3	1124.46-4663.89	523.00-940.63	55.38-104.00
C. lenticula	3.30±0.24	7.20±0.39	135.07±21.17	156.36±16.35	5.58±0.81
	2.7-3.7	6.3-8.0	101.86-186.06	115.83-193.60	4.56-8.06

follicula: p= 0.140; *R. decollata*: p= 0.353; *X. apicina*: p= 0.203; *C. acuta*: p= 0.363; *C.aspersus*: p= 0.391; *O.lactea*: p= 0.391;*T. pisana*: p= 0.203; *C. lenticula*: p= 0.611). There was no change from SCI 2 in any of the shells of any species in the controls during the experimental period.

The maximal scores attained for each species, and the days elapsed for this to occur (for both halves of the board) are shown in Table V. This table also shows the percentage of shells with the maximal SCI score.

Table VI shows the mean surface area and mean apertural area for each species and the mean number of days elapsed to attain each of the SCI scores. The species with smaller surface areas attained higher SCI scores in less time than those with larger surface areas (χ^2 test: p< 0.001). The species with smaller apertural areas attained higher SCI scores in less time than those with larger apertural areas (χ^2 test: p< 0.001).

The spherical species (*O. lactea* and *C. aspersus*) degraded the least during the experimental period (Table VI). This may be a consequence of larger surface area and apertural area, rather than geometric shape. Support for this hypothesis is provided by the degradation rates for the two cylindrical species, *F. follicula* and *R. decollata*, the former (with smaller surface area and apertural area) degrading faster than the latter. Apertural area may be related to shell size and surface area, with the larger species (which have larger surface areas) having larger apertural areas (Spearman's rho= 0.810, p= 0.015).

DISCUSSION

The larger species degraded less rapidly than the smaller species. Of all the species *C. aspersus* required the longest time interval for attainment of

Table IV. The time (in days) that 50 and 100% of shells attained each of the SCI scores. Colour refers to the white and black halves of the board onto which the shells were attached. The table shows results for the shells exposed to the sun; the shells on the control board, kept in darkness, did not change from SCI 2 during the experimental period (see text for details).

Tabla IV. El período (en días) en que el 50 y 100% de las conchas alcanzaron cada uno de los valores SCI. Colour se refiere a las mitades del tablero donde se fijaron las conchas. La tabla indica datos para las conchas expuestas al sol: las conchas control, mantenidas en oscuridad, no cambiaron el valor SCI 2 durante el período de experimentación (ver texto para detalles).

Species	Colour	Shell condition index (SCI)							
		3	3	4	4	5	5	6	6
	%	50	100	50	100	50	100	50	100
F. follicula	white	6	12	18	18	60	66	72	78
	black	3	9	18	18	51	66	72	78
R. decollata	white	12	18	51	60	84	84		
	black	12	18	51	60	84	84		
X. apicina	white	18	18	60	60	84	84		
	black	12	15	60	60	84	84		
C. acuta	white	12	12	18	18	72	72		
	black	12	12	18	18	72	72		
C. aspersus	white	51	51	84	90				
	black	51	51	84	90				
O. lactea	white	3	3	84	84				
	black	3	3	84	90				
T. pisana	white	6	6	48	48	84	90		
	black	6	6	48	48	72	84		
C. lenticula	white	15	15	42	42	60	69		
	black	18	18	33	42	60	66		

Table V. The maximal Shell Condition Index (SCI) scores attained for each species, and the days elapsed for this to occur for the white and black sides of the board. The table also shows the percentage of shells with the maximal SCI score.

Tabla V. Los valores máximos para el indice del estado de la concha (SCI) alcanzados para cada especie, y los dias que transcurrieron para estas, en las mitades blanca y negra del tablero. La tabla también indica el porcentaje de conchas con el SCI máximo.

Species	Maximal SCI		Days elapsed		% Shells with maximal SCI	
	White	Black	White	Black	White	Black
F. follicula	6	6	78	78	100	100
R. decollata	5	5	84	84	100	100
X. apicina	5	5	84	84	100	100
C. acuta	5	5	72	72	100	100
C. aspersus	5	5	111	111	10	30
O. lactea	5	5	114	111	30	40
T. pisana	5	5	90	84	100	100
C. lenticula	6	6	72	72	10	10

Table VI. The mean surface area (mm^2) and mean apertural area (mm^2) for each species and the mean number of days elapsed to attain each of the Shell Condition Index (SCI) scores.
Tabla VI. Media de area de superficie (mm^2) y media de area de abertura (mm^2) para cada especie y media de dias transcurridos para alcanzar cada uno de los valores del indice del estado de la concha (SCI).

Species	**Surface area**	**Apertural area**	**Mean number of days elapsed to SCI score**			
			3	**4**	**5**	**6**
F. follicula	112.38	7.94	10.5	18	66	78
R. decollata	873.64	44.48	18	60	84	
X. apicina	134.48	9.19	51	90		
C. acuta	118.04	10.57	12	18	72	
C. aspersus	2113.28	362.99	51	90		
O. lactea	1601.75	173.03	3	87		
T. pisana	677.28	70.27	6	48	87	
C. lenticula	156.36	5.58	16.5	42	67.5	

SCI 3 (51 days). Colour preservation depends on the chemistry and stability of pigments and on shell mineralogy and exposure to sunlight fades pigments (CLAASSEN, 1998). The periostracum in *C. aspersus* possibly protects the underlying shell layer from pigment-fading and shell degradation. *O. lactea*, lacking this protective feature, degraded to SCI 3 in only 3 days, after which SCI 4 was attained in 84 days (the same as for *C. aspersus*).

Geometric shape is possibly not as important as surface area and apertural area in degradation rate. Because apertural area may be related to shell size and surface area, it is not possible to conclude that larger surface area and apertural area result, in themselves, in decreased degradation rates (rather than large shell size *per se*).

The surface temperatures of the boards were not measured but it may be assumed that the black side absorbed and retained more heat than the white. This was not a significant factor in degradation with no difference detected between the two sides of the board. This suggests that soil and rock coloration, on which specimens in the field might be collected, is not a significant factor in shell degradation. There was no degradation on the control board and the assumption is that insolation (possibly in conjunction with other, unmeasured, factors) contributes to shell degradation.

The data provide an indication of shells that may be included in a species abundance matrix for ecological study. All species attained a maximal SCI of at least 5 (*F. follicula* and *C. lenticula* attained SCI 6, see Table V). The inclusion of shells found in the field with an SCI score lower than 5 suggests that they will have been present in a dead state for a period less than the total duration of the annual dry period. The degradation rate of each species collected would need to be measured for a high level of confidence for this decision but this would be impractical. The data show that it may be acceptable to accept an SCI score of 4 for any species as a benchmark for inclusion in species matrices.

Further work would elucidate the role of other factors in shell degradation such as pH, moisture and the effects of soil cover. The latter would be particularly relevant for substratum samples. The effects of presence or absence of the dead animal inside the shell during degradation could also be studied. Additionally, species favouring locations under substratum (rocks, logs etc.) require special caution when assigning SCI values. These species dying *in situ*

and remaining in their locations would be protected from insolation effects.

The Index provides a guide for ecological fieldwork which is an improvement over current subjective criteria used for inclusion or exclusion of shells from species matrices. It is recognized, however, that there is much scope for its refinement which would increase its value in molluscan ecology.

ACKNOWLEDGEMENTS

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Sinonimias
Doris limbata Cuvier, 1804, *Ann. Mus. H. N. Paris*, 4 (24): 468-469 [Localidad tipo: Marsella].
Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop. Car.*, 10: 275.

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Ponder, W. F., 1988. The Truncatelloidean (= Rissoacean) radiation - a preliminary phylogeny. En Ponder, W. F. (Ed.): Prosobranch Phylogeny, *Malacological Review*, suppl. 4: 129-166.

Ros, J., 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoolgica*, 3 (5): 21-51.

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Dendrodoris limbata **(Cuvier, 1804)**
Synonyms
Doris limbata Cuvier, 1804, *Ann. Mus. H. N. Paris*, 4 (24): 468-469 [Type locality: Marseille].
Doris nigricans Otto, 1823, *Nov. Act. Ac. Caes. Leop. Car.*, 10: 275.

These references must not be included in the Bibliography list, except if referred to elsewhere in the text. If a full list of references of the taxon is to be given immediately below it, the same layout should be followed (also excluding those nowhere else cited from the Bibliography list).

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Ros, J., 1976. Catálogo provisional de los Opistobranquios (Gastropoda: Euthyneura) de las costas ibéricas. *Miscelánea Zoológica*, 3 (5): 21-51.

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ÍNDICE

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